CHAPTER 4

STILL CAMERAS AND CONTROLS

Cameras have gone through many changes in design over the years. Several of your chiefs and division officers remember lugging around bulky, cumbersome 4x5 Speed Graphic cameras with film holders and tripods just to cover routine assignments. Through the development of modern-day cameras and film, small, hand-held cameras are commonly used. A large variety of cameras are available in the imaging facilities of the Navy. After learning the nature of your assignment and the equipment available, you must choose the equipment that will get the job done best, whether it be a 4x5 view camera or a small, hand-held electronic camera.

The human eye may be compared to a camera There are several similarities. The eye is a physiological optical instrument. The camera is a mechanical optical instrument. The eye has a lens, and like the lens of a camera, it forms an image on a light-sensitive surface (fig. 4-1). The lens of the eye focuses light on the retina. The camera lens focuses light on the film plane. The lens of the eye focuses by changing its curvature, the camera lens by changing its focal length. The diaphragm on a camera is similar, like the iris of the eye. When the light is bright, the iris closes down, reducing the brightness of the image. Likewise, when the light is bright, the camera diaphragm closes down When the light is dim, the diaphragm opens up. The components of the eye are held together by the sclera, the components of the camera by the camera body.

A camera in its simplest form (fig. 4-2) is a lighttight box with a lens to form an image, a shutter to control the length of time light is allowed to act on the film, a

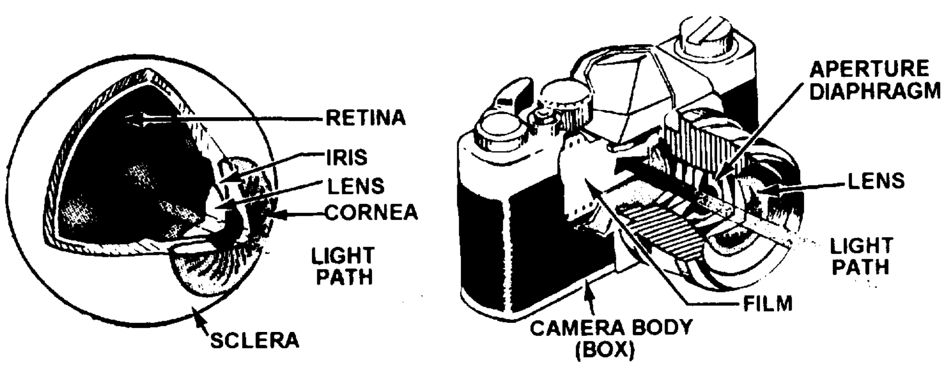

Figure 4-1.–Comparison of human eye to a camera.

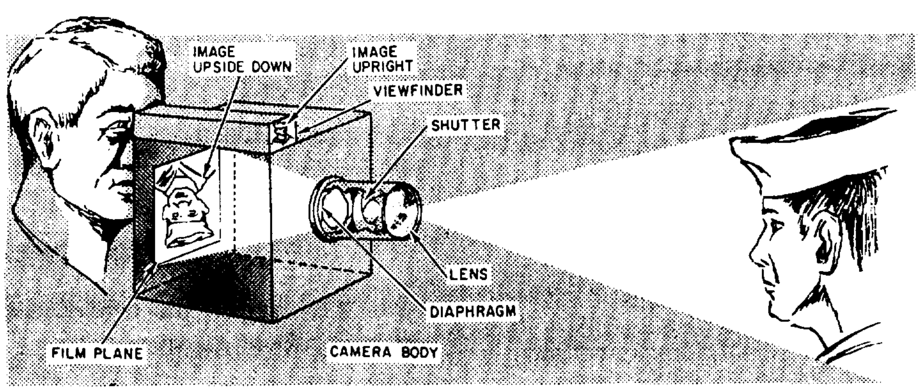

Figure 4-2.–A simple camera.

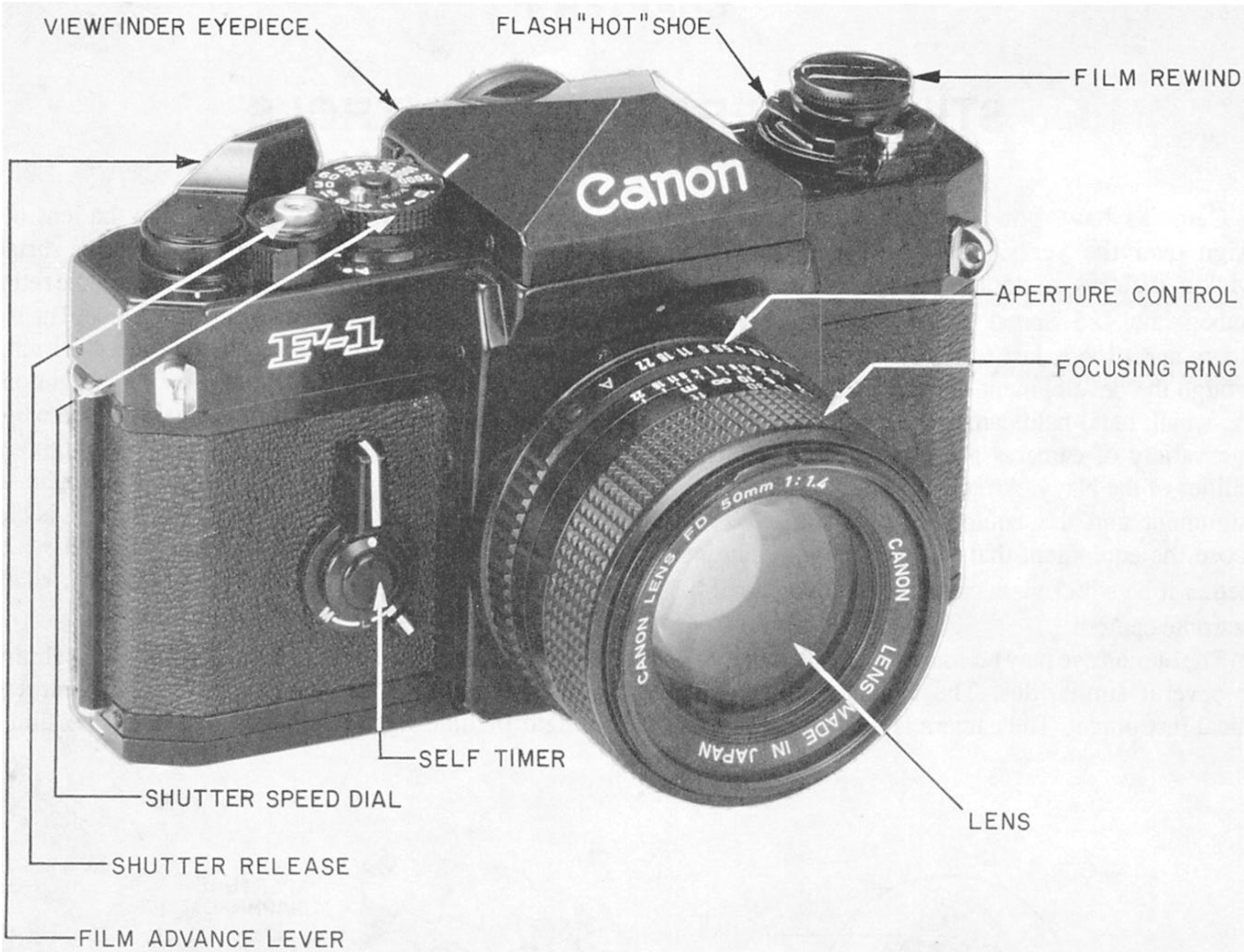

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Figure 4-3.–35mm single-lens reflex (SLR) camera.

diaphragm to control the brightness of the image, a means of holding the film at the back of the camera, and a viewfinder so the photographer knows what the image is, and of course a body to hold it all together.

Simple cameras, such as the one described, have limited capabilities. They have a fixed-focus lens that cannot produce a sharp image of a subject closer than about 6 feet. Also, the shutter speed and diaphragm are preset and cannot be altered. The capabilities of a simple camera can be enhanced by adding features to perform the following:

- Focus on subjects at various distances
- Adjust the lens for different lighting conditions
- Change various lenses quickly to change focal length and fields of view
- Change shutter speed to "capture" images of moving subjects
- Use synchronized electronic flash
- Meter the image brightness of the subject to either manually or automatically adjust the diaphragm and shutter speed

Figure 4-3 illustrates a common 35mm camera and identifies the various camera controls.

CAMERA TYPES

In this chapter, the characteristics and functions commonly found on most cameras are discussed. No single camera can meet the requirements of every photographic assignment. There are a number of cameras to choose from in the fleet. These cameras

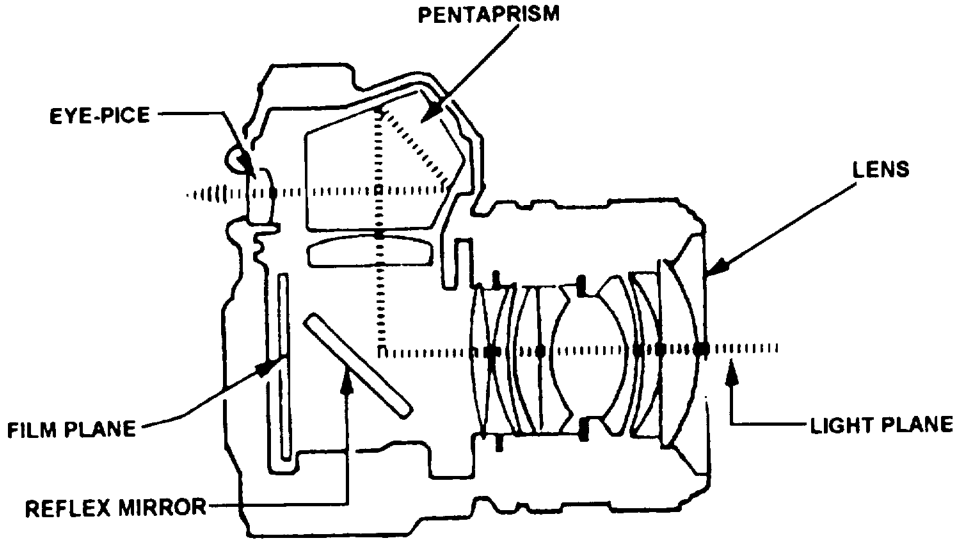

Figure 4-4.–Design of a typical SLR camera.

produce negatives that range in size from 35mm to 8x10 inches. You will learn to choose the camera that best meets the conditions of your assignment and the customer's photographic requirements.

The number and types of cameras available at an imaging facility depend primarily on the mission of the facility. All cameras have common features. Once you become familiar with the operation of one camera, you can learn quickly to operate other types. There are three general categories of cameras: small format, medium format, and large format.

SMALL-FORMAT CAMERAS

Cameras that produce negatives smaller than 35mm are considered small-format cameras. Small-format cameras are preferable when you need maximum freedom of movement and a large number of negatives without reloading the camera. The accessories, lenses, and flash equipment can be carried easily, and commonly 36 frames may be taken rapidly without reloading the film. This type of camera is helpful for news and action photography where several pictures must be taken in a short time from various ranges and under varying light conditions. The primary disadvantage of small-format cameras is they produce small negatives. The smaller the negative, the more it must be enlarged in printing.

The most popular professional small-format camera is the 35mm single-lens reflex (SLR). This camera has a mirror in the path of the image formed by the lens that is reflected to a viewing screen for focusing and composition. This allows you to see what the lens sees regardless of the lens focal length or the lens-to-subject distance. The reflex system is simple and reliable. It has three main elements: a hinged mirror, a matte focusing screen, and a five-sided glass prism called a pentaprism The mirror, in the viewing position, is below the viewing screen and behind the lens. It is at a 45-degree angle and projects the image formed by the lens up to the focusing or viewing screen. The pentaprism reflects the image from the focusing screen, so you can see it in the camera eyepiece. Figure 4-4 shows the design of a typical SLR camera.

When the shutter release is pressed, the mirror swings up and out of the light path, so the light can reach the film. It also seals off the viewfinder, so light entering the eyepiece cannot reach the film. After the film is exposed, the mirror swings back down, and the image is visible again in the viewfinder.

CAUTION

The reflex mirror is thin glass coated on the front with silver, so care must be taken not to damage it by touching or scratching it. Follow only the procedures listed in the Planned Maintenance System (PMS) for cleaning camera mirrors.

Almost all 35mm cameras have focal-plane shutters. Focal-plane shutters simplify the construction of the camera and make interchangeable lenses smaller,

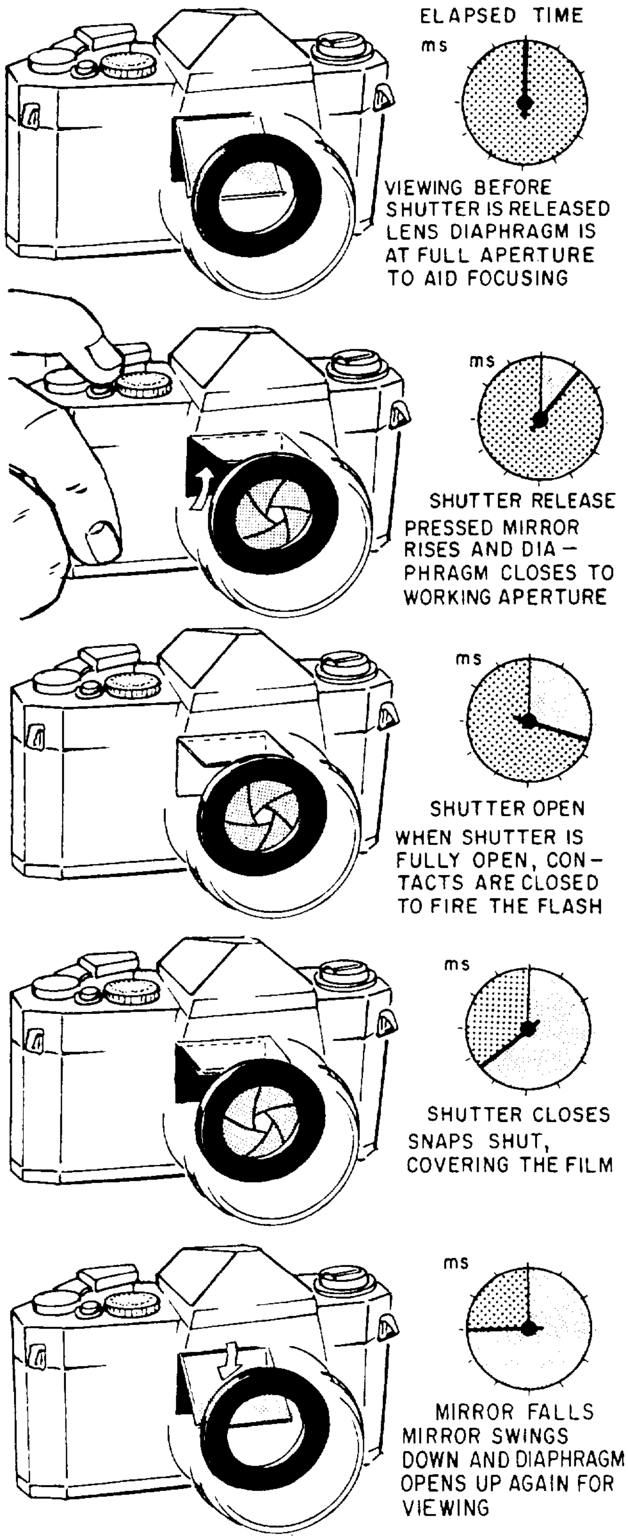

Figure 4-5.–The shutter, aperture, and mirror operate in a precke sequence when exposures are made.

lighter, and less expensive. The shutter, aperture, and mirror work together in a precise sequence that is repeated each time the shutter is tripped (fig. 4-5).

Most SLR lenses have an iris diaphragm. The diaphragm is held wide open for focusing and viewing. The aperture is then stopped down automatically to the preset working aperture at the instant the exposure is made. That means the image on the viewing screen is bright, easy to see, and focus; but only controlled brightness reaches the film for exposure.

Focusing is done by turning the lens focusing ring. A screw thread that runs around the inside of the lens barrel moves the lens closer or farther away from the film as the focusing ring is turned. The interchangeable lenses of most 35mm cameras are attached by a bayonet flange. Each lens mount differs slightly for each manufacturer of lenses and cameras, thus different lenses and camera bodies cannot be interchanged.

Most 35mm SLRs have a built-in light meter that reads through the lens (TTL). The light meter may read the light falling on the mirror, the shutter curtain, the focusing screen, or even on the film at the instant of exposure. On an automatic camera, the f/stop or shutter speed is adjusted automatically for correct exposures. On manual cameras, the light meter produces a display in the viewfinder to indicate the correct camera settings. You must then set the camera controls to get the correct exposures.

MEDIUM-FORMAT CAMERAS

Medium-format cameras are very popular in Navy imaging facilities. Except for the increased size, these cameras are just as versatile as small-format cameras. Interchangeable lenses, TTL metering, SLR focusing systems, and both manual and automatic controls are available on medium-format cameras. The advantage of a medium-format camera is the larger negative size of 120 or 220 film. These cameras are commonly used for portraiture or when relatively large prints are required from the negative. The most common medium-format camera used by Navy imaging facilities is the Bronica ETRS (fig. 4-6). This camera is available in almost all Navy imaging facilities, both afloat and ashore.

LARGE-FORMAT CAMERAS

Large-format cameras are used when you must retain maximum detail in the negative. This is necessary when certain subjects are photographed to exact scale or when large prints are required. Large-format cameras produce negatives 4x5 or larger. The most common large-format cameras are view cameras and copy cameras. Features common to all large-format cameras are as follows:

- Ground glass viewing and focusing

Courtesy of Tamron Industries, Inc.
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Figure 4-6.–Bronica ETRS medium-format camera.

- Both front and rear focusing
- Bellows that extend to permit at least a 1:1 image ratio

In addition to the features listed above, the view camera has additional features that control image sharpness and distortion. The view camera is discussed later in this chapter.

CAMERA CONTROLS

When you take a picture, the camera causes light reflected from the subject to be imaged on light-sensitive material. The camera controls this action in several ways. The first control is focus. Cameras have components to show what part of the scene will be recorded in sharp focus on the film. For example, some cameras use a coincidence or split-image range finder, and others use a focusing screen or ground glass.

The second camera control is the **lens aperture.** This control is located next to the focusing ring on most cameras. As discussed in chapter 1, the aperture affects both focus and exposure.

The third control is **shutter speed.** The shutter controls the length of time light is admitted to the film. Shutter speed also has an effect on the way movement is recorded on film.

FOCUS

Focusing involves adjusting the distance between the lens and the focal plane, or film plane, when photographing subjects at various camera-to-subject distances. When a camera lens is focused on a subject point, all light rays from that point, and only that point, are brought to sharp focus at the film plane. When about 600 or more feet from the camera, the subject is considered to be at infinity. A subject at infinity is so far from the camera that rays of light reflected to the lens from the subject are considered parallel. When a camera is focused on a subject at infinity, the distance between the optical center of the lens and the film plane (lens-to-film distance) is equal to the lens focal length. At this point the lens is closest to the film plane. As the camera-to-subject distance decreases, the lens-to-film distance must be increased to bring the subject into focus.

When you are taking a picture of only one subject, focusing is simple; however, when you want to include several subjects at different distances from the camera in the same picture and have them all in sharp focus, it becomes more complicated. Unless the subject is distant scenery with nothing in the foreground, there is always one object that is closer to the camera than another. Then you must decide what part of the scene is to appear in sharp focus. In simple cases, such as a sailor standing against a plain background, the decision is simple-focus on the sailor. In more complex cases, when subjects both close and far from the camera must be in sharp focus, you should focus about one third of the distance into the scene. In other words, focus about one third of the distance between the closest and farthest subject you want in sharp focus. This is known as the **depth of field.**

The way you focus the camera will depend on what part of the picture is most important and its purpose; for example, the pictures a civil engineer needs of a building at a naval air station is altogether different from the pictures a visitor to the air station wants to take home. The engineer needs pictures that show a maximum amount of detail throughout the scene. The visitor, on the other hand, is more interested in pictures that bring back pleasant memories. The requirements of the picture determine what you should focus on. The engineer needs to have everything in the picture in sharp focus. You might accomplish this as follows: Measure the distance to the nearest point of the picture and the distance to the farthest part of the scene. Then consult the depth-of-field scale on the camera lens to focus on a point between these two distances. Now, when the lens is stopped down to a small aperture, the depth of field is

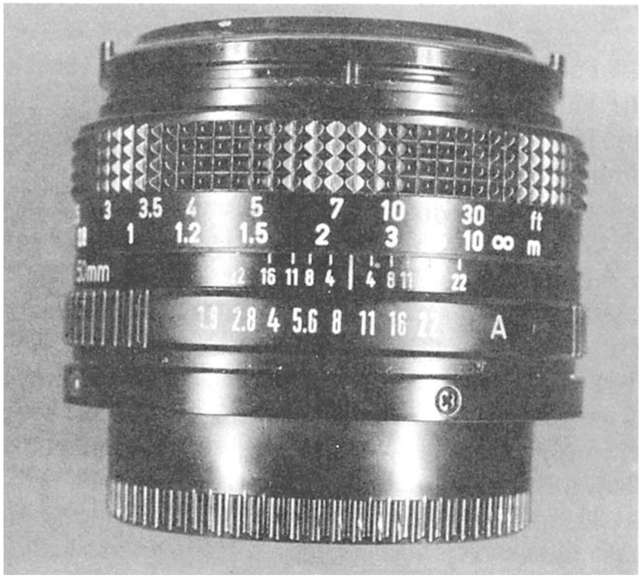

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Figure 4-7.–Focusing scale.

increased. Both near and far points will appear in focus. In photographing the scene for a visitor, you may want to emphasize only the entrance way to the building, rather than concentrating on getting everything in the picture in sharp focus.

Focusing Systems

Accurate focusing and framing are essential to good pictures, and modern cameras have many devices to help you get good focusing and framing results.

Because of the principles of depth of field, simple cameras are manufactured without any way of adjusting focus. The lenses of these simple cameras are prefocused at the hyperfocal distance. Remember from chapter 1, that the hyperfocal distance for a lens is determined by the focal length and the aperture. That allows "point and shoot," ID, and passport cameras to produce pictures where everything from about one half of the hyperfocal distance through infinity are acceptably sharp.

Focusing is accomplished by adjusting the distance from the lens to the film. It does not matter which of the two is actually moved, the lens or the film. With hand-held cameras the lens is moved in and out. Usually on large-copy cameras, the camera back (film plane) is moved toward or away from the lens, That is because the distance from the photographer to the lens board is usually too great to focus through the ground glass.

No matter what system you use to focus the camera, there must be a means for you to determine when the image is in focus. Some cameras have autofocusing systems. Most camera systems used by Navy personnel are focused manually.

Focusing Scale

This is the simplest type of focusing system. It uses a scale of distances that indicates the distance where the focus is set. Primarily, these scales are engraved on the lens barrel. To use the focusing scale, you can measure the camera-to-subject distance, but, in most cases, you must estimate the camera-to-subject distance. This distance is then set to the focus index mark on the lens (fig. 4-7). Scale focusing can be useful when you anticipate quick action but do not have sufficient time to focus the camera. When using scale focusing, a small f/stop is helpful so you can rely on depth of field to provide an acceptably sharp image.

Ground Glass Focusing

With some cameras, focusing is done by viewing the image on a glass screen, called a ground glass. The image formed by a view camera is projected directly to the ground glass for viewing and focusing. Accurate focusing can be achieved using a ground glass. There is a drawback to this type of focusing. Because of the texture of the ground glass, very fine detail of the image is difficult to distinguish. That results in some leeway in focusing. Additionally, when you work too long at focusing the image, your eye will adjust and accept an image that is less than sharp. For this reason, it is helpful to place a magnifying loop directly on the ground glass. That helps in focusing quickly and accurately.

A ground glass focusing system shows directly the image that will appear on the film. The image size and depth of field records on the film the same as it appears on the ground glass. Ground glass focusing systems are commonly found on copy cameras and view cameras. The image on the ground glass appears upside down and backwards.

Reflex Focusing

A reflex focusing system also uses a ground glass or focusing screen; however, instead of the image being

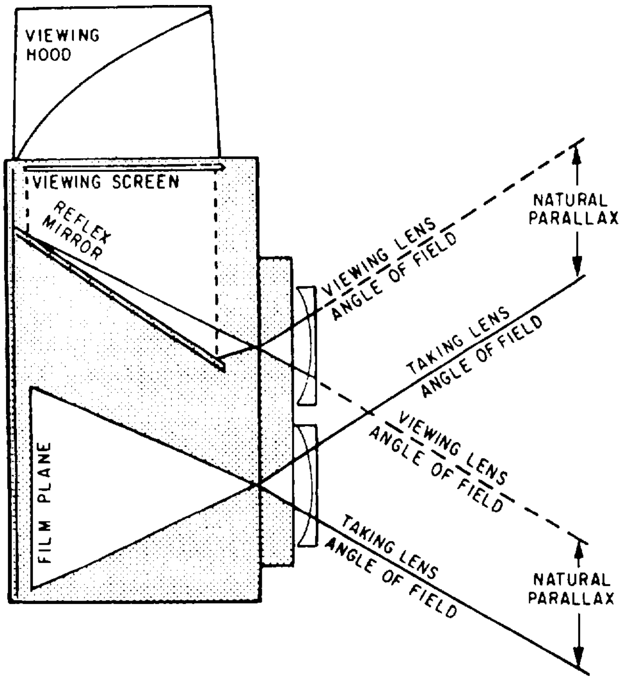

Figure 4-8.–Twin-lens reflex camera.

formed directly on the ground glass or focusing screen, the lens forms the image on a mirror that reflects the image to the focusing screen or ground glass.

TWIN-LENS REFLEX.–The twin-lens reflex (TLR) system uses a matched set of lenses for focusing and viewing. One lens is the viewing lens; the other is the picture-taking lens. The viewing lens is always wide open. That makes focusing and viewing easy, but depth of field cannot be viewed. Depth of field must be determined by a scale that is provided on the lens or camera body.

An advantage of the twin-lens reflex system is that the image is visible on the focusing screen, before, during, and after exposure. A disadvantage of twin-lens systems is that parallax errors occur. Parallax refers to the difference between the image seen through the viewing lens and the image transmitted to the picture-taking lens (fig. 4-8). For distant subjects the difference is not very great or noticeable; however, when your subject is close to the camera, parallax is much more noticeable. You see a different image area through the viewing lens than what is being transmitted through the picture-taking lens. Some twin-lens reflex cameras have an indicator in the viewing lens, so you can compensate for parallax. Another disadvantage of the twin-lens reflex camera is that it takes practice to

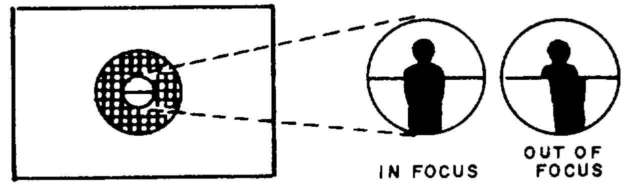

Figure 4-9.–Split-image focusing.

follow action and compose the subject. The image seen on the focusing screen is backwards from the actual image. Twin-lens reflex cameras are no longer commonly used in Navy imaging, but they are still around.

SINGLE-LENS REFLEX.–Single-lens reflex (SLR) cameras have a focusing and viewing system that shows you the image formed by the picture-taking lens. SLR cameras are designed so the distance between the focusing screen and the lens is exactly the same as the distance between the lens and the film; therefore, whatever appears in focus on the focusing screen will also be recorded in focus on the film. With an SLR camera, there is no parallax error.

Sometimes two small prisms or a split screen is included in the central area of an SLR camera viewing screen. When the image is out of focus, it appears split in this area (fig. 4-9). Some screens have a central grid of minute prisms that produce a shimmering effect when the image is out of focus.

An SLR camera is focused by rotating the focusing ring on the lens until the image seen through the viewfinder is in sharp focus. SLR cameras are the most commonly used camera in Navy imaging today.

Direct-Vision Range Finder Focusing

Cameras that use direct-vision range finder focusing produce a double image in the viewfinder until the subject is in focus on the film plane. This system has a coupled range finder optical device that is linked to the focusing ring. To focus a direct-vision coincidence or split-image range finder camera, you must align two separate images of the subject. When looking through the camera viewfinder, you see a pale or tinted area in the center of the viewing window. This area shows the double image. To set the correct focus, you aim the camera so the subject you want in sharpest focus is in the pale area. You then turn the lens focus ring, or camera

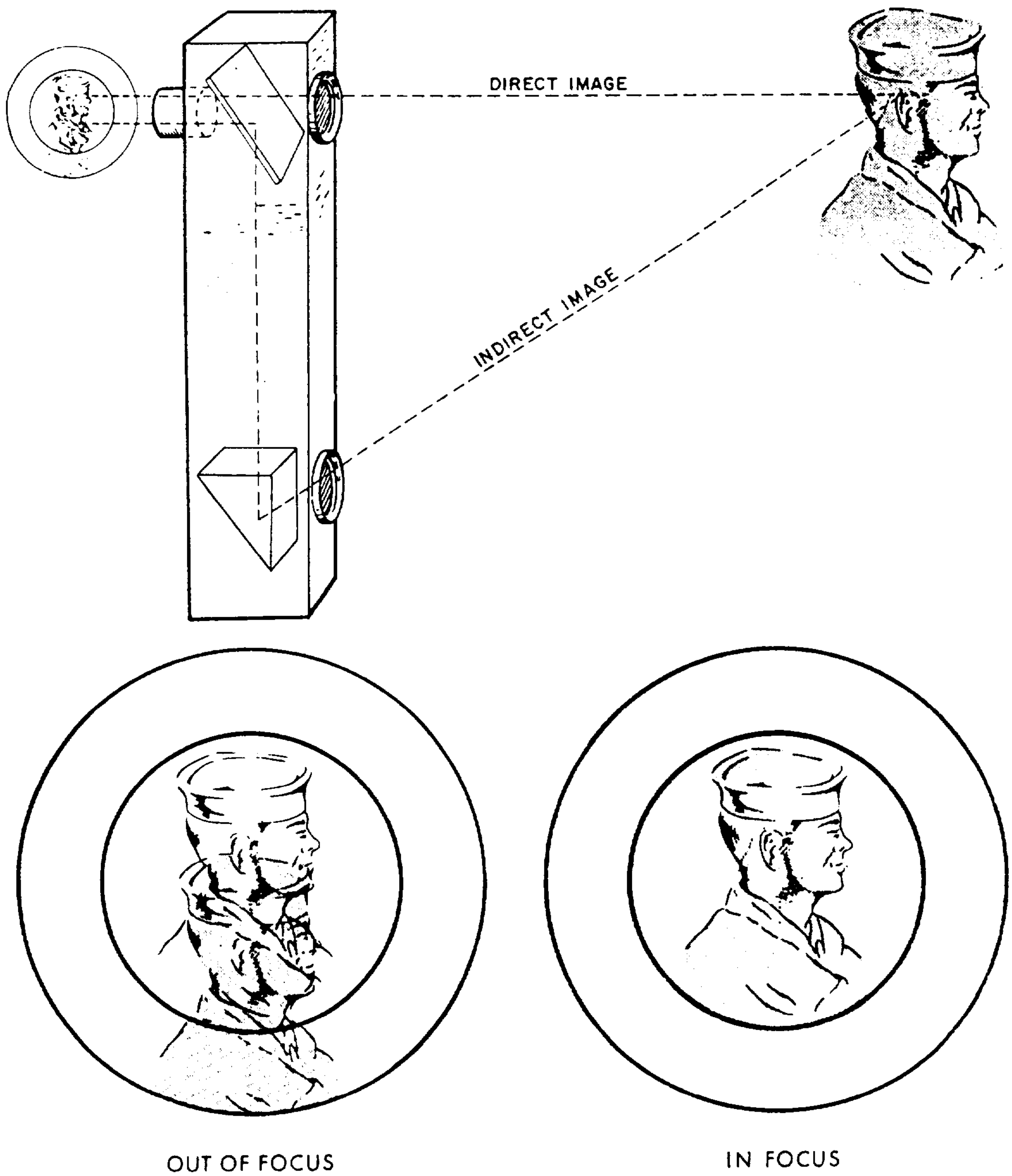

Figure 4-10.–Direct-vision range finder focusing.

focus knob, until the double images coincide and only one image is seen (fig. 4-10).

The disadvantages of a direct range finder system are that it does not couple to a large variety of lenses, thus restricting its use to only several different focal-length lenses. Unlike the ground glass and SLR focusing systems, depth of field cannot be determined in the direct-vision range finder system. Everything appears sharp through the viewfinder window.

Autofocus

Most autofocus cameras use the same principle as a direct-vision range finder camera. The autofocus camera determines the subject distance by comparing

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Figure 4-11.–Use of selective focus.

the contrast brightness of two images: one reflected from a fixed mirror, the other from a movable mirror. This system works on the theory that the sharpest images have the highest contrast. When maximum contrast is reached, an electronic device converts the contrast brightness information into impulses. These impulses start a motor that moves the lens to the point of sharp focus. This type of autofocus system does not perform effectively when the subject is all one color or does not contain much contrast.

Another type of autofocus camera uses sonar or infrared These systems emit either a sonar or infrared signal to determine subject distance. The distance is determined by the amount of time it takes the transmitted energy to reflect back from the subject to a sensor on the camera. This information is then sent to a motor that moves the lens to the point of sharp focus. The sonar autofocus system has a disadvantage. You cannot photograph subjects through glass. The sonar reflects off the glass and not the subject.

SELECTIVE FOCUS

You do not always want everything in your photographs to be in sharp focus. By using selective focus, you can emphasize the main subject and draw attention to it. "Selective focus" means the use of a shallow depth of field to isolate or emphasize the subject (fig. 4-11). Selective focus is the control of the zone of sharpness, or depth of field, in your photographs.

Once the lens has been focused on the main subject of the picture, using a progressively larger aperture (f/stop) will reduce the zone in front of and behind the subject that is in focus. Long-focal-length lenses are more effective for selective focusing because of their larger real apertures. Wide-angle or short-focal-length lenses are not as effective for selective focus because of the great depth of field they provide at most apertures. The following factors provide the maximum selective focus control by minimizing depth of field:

- Working close-up
- Using a wide aperture

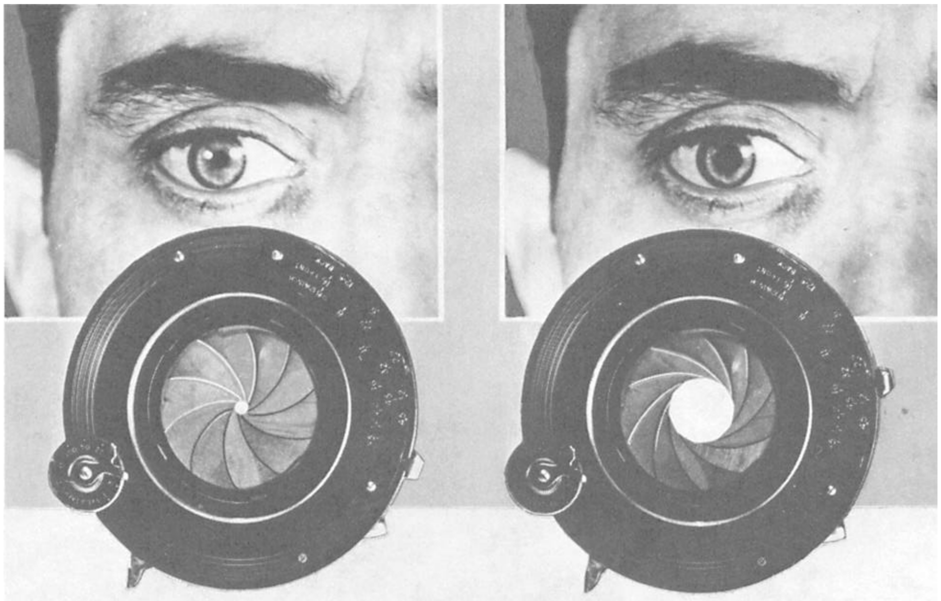

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Figure 4-12.–Iris diaphragm.

- Using a long-focal-length lens
- Focusing on near objects

APERTURE

The aperture, or f/stop as it is commonly called, is used to regulate the diameter of the lens opening. That controls the luminance on the film plane. Besides controlling the luminance on the film plane, the f/stop also controls image sharpness by partially correcting various lens aberrations.

The most commonly used aperture control device is the iris diaphragm. An iris diaphragm is an adjustable device that is fitted into the barrel of the lens or shutter housing. It is called an iris diaphragm because it resembles the iris in the human eye (fig. 4-12). An iris diaphragm is a series of thin, curved, metal blades that overlap each other and is fastened to a ring on the lens barrel or shutter housing. The size of the aperture is changed by turning the aperture control ring. The blades move in unison as the control ring is moved, forming an aperture of any desired size. The control ring is marked in a series of f/stops that relate to the iris opening. The aperture controls the **intensity** of light that is allowed to pass to the film and the parts of the image that will appear in sharp focus.

Depth of Field

Depth of field is that zone both in front of and behind your subject that are in acceptably sharp focus. The focusing controls on most cameras are easy to use, providing you understand the factors that effect depth of field. To produce professional quality photographs, you must know how to control the depth of field.

Aperture, or f/stop, is the most important factor in controlling the depth of field. The smaller the f/stop opening, the greater the depth of field; for example, at f/16, a normal lens focused on a subject 16 feet from the camera may show everything in focus from 8 feet to infinity. At f/5.6, depth of field may range from about 3 feet in front of the subject to about 6 feet behind the subject. At f/2, only the subject focused on is sharp. As shown in figure 4-3, a shallow depth of field results in a blurry foreground and background, whereas greater depth of field results in more overall sharpness.

Camera-to-subject distance also has an effect on the depth of field. In general, the closer you are to the subject, the shallower the depth of field. Even at f/16 with a normal lens, if you focus on a subject only 3 feet from the camera, the depth of field may only be about 1 foot. At f/2, the subject's eyes may be in sharp focus, but the nose and ears are blurred. As you increase the camera-to-subject distance, the depth of field increases rapidly. Using an aperture of f/16 and focusing at 6 feet, the depth of field may extend from a foot in front of the subject to about 3 feet in back of the subject. Still using

Table 4-1.–How to Control Depth of Field

If you want less	If you want more
Use a larger f/stop (lower number).	Use a smaller f/stop (higher number).
Use a longer focal length lens.	Use a shorter focal length lens.
Move closer to the subject.	Back up from the subject.
Use a filter to reduce the amount of light allowed to be transmitted and use a larger f/stop.	Use a faster film or a slower shutter speed and use a smaller f/stop.
	Focus at the hyperfocal distance.

f/16 but focusing now at about 16 feet, the depth of field is almost at infinity. Most normal lenses for 35mm cameras produce these maximum ranges of sharpness at about 16 feet. Focusing any farther from the camera only reduces foreground sharpness. You must remember this point when attempting to get the greatest possible depth of field.

Lens focal length is also a factor in depth of field. The shorter the lens focal length, the greater the depth of field at a given aperture. In other words, a wide-angle lens provides more depth of field at f/8 than a normal lens, and a normal lens provides more depth of field at f/8 than a telephoto lens.

You know that a small aperture like f/16 provides more depth of field than a wide aperture like f/2. With experience, you can predict the best aperture for the depth of field desired. Even with experience, you do not always have to guess the aperture setting or calculate the hyperfocal distance, near distance, and far distance by using formulas. Most lenses have a depth-of-field scale to guide you (fig. 4-13). The depth-of-field scale indicates the distance range from the camera that the subject(s) appear in acceptably sharp focus. The depth of field on an SLR is marked between the aperture ring and the focusing scale. Use the depth-of-field scale as follows:

1. Focus on the subject.
2. Select the f/stop.
3. Look at the depth-of-field scale and locate the marks that correspond to your chosen f/stop. The f/stop appears twice, once on either side of the scale center line.
4. Read the two distances on the focusing scale that are adjacent to the two f/stops on the depth-of-field scale. You may have to estimate the distances.

You can see in figure 4-13 that the lens is focused at a distance of 30 feet with the aperture set between f/16 and f/22. You can see from the depth-of-field scale that the depth of field extends from approximately 11 feet to beyond infinity. If the aperture is opened up to f/8, the depth of field will range from about 16 feet to infinity.

At any given aperture, depth of field is maximized by focusing the lens at the hyperfocal distance. That is the closest point of acceptable sharp focus shown on the depth-of-field scale when the lens is focused at infinity. When you are changing the focus setting to the hyperfocal distance, the zone in front of the subject that is sharp is increased, and infinity is still the farthest point

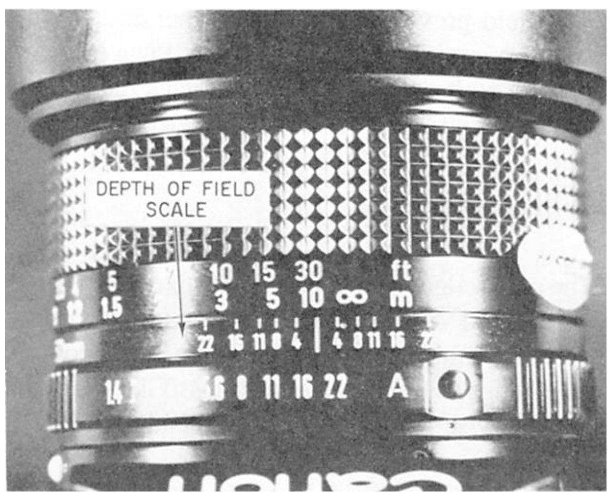

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Figure 4-13.–Depth-of-field scale.

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Figure 4-14.–When the lens is focused at 20 feet and set at f/22, the depth of field ranges from about 10 feet to infinity

in sharp focus. In figure 4-14, when the lens is set at f/22 and focused at infinity, the depth of field ranges from about 20 feet (the hyperfocal distance) to infinity; however, when you change the lens focus to 20 feet, the depth of field ranges from about 10 feet to infinity.

The lenses of modern SLR cameras stay at their maximum aperture until the shutter is tripped. These lenses provide a bright image in the viewfinder to focus. As a result, when you look through the viewfinder, you only see the depth of field for the maximum aperture and not the working f/stop. Most SLR cameras have a depth-of-field preview button to compensate for this. When you press it, the aperture closes down to the set f/stop. Although the viewfinder becomes darker, you can see the actual depth of field at the selected aperture.

Image Sharpness

The outer edges of a lens are least likely to produce a well-defined or aberration-free image; therefore, proper use of the diaphragm, aperture, or f/stop can improve image sharpness by blocking off light rays that would otherwise pass through the outside edges of a lens.

There is a limit to how far the aperture can be stopped down and still increase image sharpness. When the aperture is very small, it causes diffraction of light rays striking the edge of the diaphragm. Diffraction results in a loss of image sharpness. This loss of image sharpness is especially noticeable in copy work

Physical limitations in the design of lenses make it impossible to manufacture a lens of uniform quality from the center to the edges; therefore, to obtain the best quality with most lenses, you can eliminate the edges of the lens from being used by closing down the aperture about two f/stops from wide open This recommended adjustment is called the **optimum** or **critical aperture.** The optimum aperture for a particular lens refers to the f/stop that renders the best image definition.

When a lens is stopped down below the optimum aperture, there is an actual decrease in overall image sharpness due to diffraction. Although the depth of field increases when a lens is stopped down below the optimum aperture, image sharpness decreases; therefore, increased depth of field should not be confused with image sharpness. For example, the image formed by a pinhole camera has extraordinary depth of field but lacks image sharpness. When the lens aperture is closed down to the size of a pinhole, it behaves like one. This is an important factor for subjects in a flat plane (such as copying) where depth of field is not needed.

SHUTTER

A camera shutter controls both the exact instant when the film is exposed to light and the duration of that exposure. The shutter is used in conjunction with the diaphragm to control the exposure of the film. The most important function of the shutter is that it limits the time that light is allowed to pass through the lens and act on the film. There are two types of camera shutters: leaf and focal plane.

Leaf Shutter

The blades of this type of shutter are usually located between or near the lens elements and close to the diaphragm. It is sometimes called a between-the-lens shutter; however, a more correct term for this type of shutter is a leaf or diaphragm shutter.

Leaf shutters have several blades made of thin spring steel. When the shutter is closed, these blades, or leaves, are at rest and overlap each other. This prevents light from reaching the film. When the shutter release button is pressed, the blades move apart or open quickly and allow light to pass and expose the film. They remain open for the duration of the preset exposure time before springing shut again (fig. 4-15).

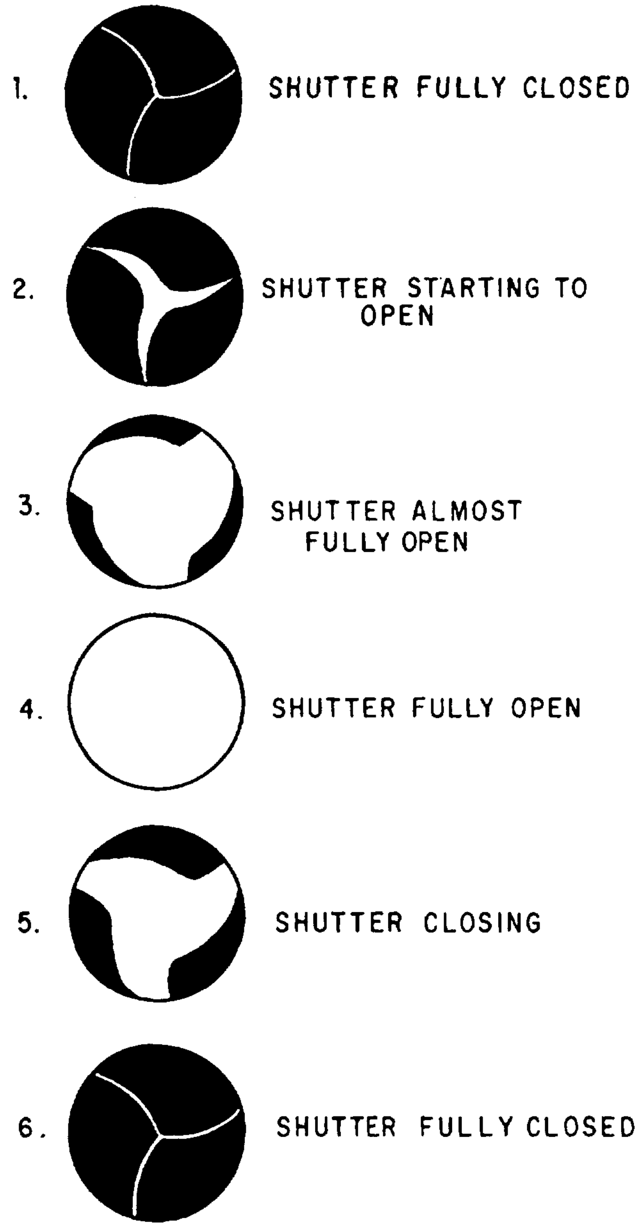

Figure 4-15.–Leaf shutter operation.

Leaf shutters have an important advantage over focal-plane shutters. Leaf shutters can be used with electronic flash at all shutter speeds. This is not true with focal-plane shutters. Focal-plane shutters can only be used at slow shutter speeds, usually at 1/125 second and below.

Focal-Plane Shutter

A focal-plane shutter is essentially two lightproof cloths or thin metal curtains that move across the film aperture in the same direction. This type of shutter is housed entirely within the camera body and is mounted on two rollers, one on each side of the film aperture

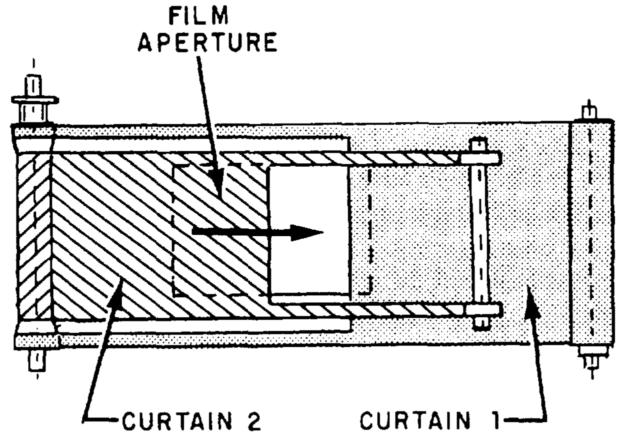

Figure 4-16.–Focal-plane shutter.

(fig. 4-16). As the curtain is moved from one roller to the other by spring tension, the second curtain follows, forming an opening that permits light to pass from the lens to the film. After the opening has passed, the second curtain stops and prevents additional light from reaching the film. In the design of focal-plane shutters, the curtains form a slit that travels across the film aperture to expose the film. When a slow shutter speed is set, the second curtain waits a relatively long time before it follows the first curtain; in this case, the slit is quite wide. When a fast shutter speed is set, the second curtain quickly follows the first and only a narrow slit is formed.

Shutter Speed

A range of shutter speeds is available on professional cameras. Common shutter settings are as follows: T, B, 1 second, 1/2, 1/4, 1/8, 1/15, 1/30, 1/60, 1/125, 1/250, 1/500, 1/1000, and 1/2000 second. The fastest between-the-lens (leaf) shutter speed is 1/500 second. Some focal-plane shutters can be as fast as 1/12000 second. In addition to a given set range of speeds, most shutters are made so they can be opened for an indefinite period of time. At the setting marked "T" (time), the shutter opens the first time the shutter release button is depressed and remains open until the shutter release button is depressed again. At the setting marked “B” (bulb), the shutter remains open as long as the shutter release button is depressed, but closes as soon as it is released.

The interval that you want the shutter to remain open is selected by moving a lever or shutter speed dial to that particular setting on the shutter speed scale. Unlike f/stops, the shutter speed you select must align exactly with the index mark You cannot select a shutter speed in between two indicated shutter speeds. On the shutter speed dial, the top part of the fraction (numerator) is not indicated; for example, the shutter speeds 1/60, 1/125, 1/250, and so forth, are indicated as 60, 125, and 250.

When a camera with a focal-plane shutter is used with an electronic flash, a predetermined shutter speed must be set. At this speed the shutter and flash unit are said to be in synchronization. When the flash and shutter are synchronized, the shutter opening is wide open at the same instant the flash fires. Usually, the slowest shutter speed that syncs with a flash unit is indicated in red or another off color or a lightning bolt symbol on the shutter speed dial.

Function

The shutter serves two functions: controlling the duration of the exposure and controlling subject movement. These two functions are entirely separate and distinct. You must determine the shutter speed required for each condition. After determining the shutter speed, you select the f/stop that provides the correct exposure for the film speed and lighting conditions. Normally, the duration of exposure is short enough to prevent image blurring. You can always set the shutter speed faster than the speed required to stop image motion, but it should not be longer if you want the image to be sharp; for example, when a shutter speed of 1/125 is sufficient to stop subject motion, you can set the shutter speed to 1/250 or faster, but not at 1/60 if you want to stop the motion and produce a sharp image. Each time you change the shutter speed, the diaphragm is adjusted to produce a properly exposed image.

The correct sequence in determining the diaphragm and shutter to produce a properly exposed negative is as follows:

1. Compose and focus the image.
2. Stop down or open up the diaphragm until the desired depth of field is achieved.
3. Select the shutter speed that will produce a proper exposure when combined with your aperture setting.
4. Determine whether the shutter speed is fast enough to prevent image blurring.
5. If the selected shutter speed is too slow, reset it to a faster speed and open up the aperture accordingly.

When you increase the shutter speed, you compromise and loose depth of field. Sometimes this is the only way to produce a useable image. If you cannot sacrifice some depth of field, there are several alternative you can use: select a faster film, increase the camera-to-subject distance, select a shorter focal length lens, or change the camera angle, so the relative motion of the subject to the camera is decreased.

Selecting the Shutter Speed

Knowing what shutter speed produces the right effect for each picture is a skill you, as a Navy Photographer's Mate, must acquire. Your pictures may easily be spoiled by movement of either the camera or the subject. In some instances, this movement can actually improve your photographs.

Novice photographers often find it hard to believe anything can happen during the brief instant the camera shutter is open. This is not true; images can be blurred when a shutter speed as fast as 1/250 of a second is used; for example, when the camera or subject moves during the fraction of a second the shutter is open, the image may be recorded on the film as a blur. Blurring caused by camera movement is noticeable in all images within the photograph. When blurring is caused by subject movement only, the background or some other part of the scene will be sharp, and the subject blurred. Camera movement blur can be corrected by supporting the camera properly or by using a faster shutter speed. Subject image movement can be reduced by using either a faster shutter speed or by panning the subject.

As explained previously, when a faster shutter speed is used, a wider aperture is required to produce correct exposure. For this reason you should know what minimum shutter speed is required to stop or freeze different actions. You must take into account conditions that exist when taking photographs. Strong winds, vibrations, or a ship rolling from side to side must be considered. There is a general rule you must follow for determining shutter speed when handholding a camera. The slowest shutter speed recommended to prevent camera movement blur is to set the shutter speed so it matches the focal length of the lens. When a shutter speed does not exist for the focal length of the lens, select the next highest shutter speed; for example, 1/30 second for a 25mm lens, 1/50 second for a 50mm lens, 1/125 second for a 100mm lens, 1/250 second for a 200mm lens, and so forth.

When a subject is in motion during exposure, the image on the film also moves. Even though the duration of exposure may only be 1/1000 of a second, the image moves a small fraction of an inch during this time. The problem you encounter is how much image movement

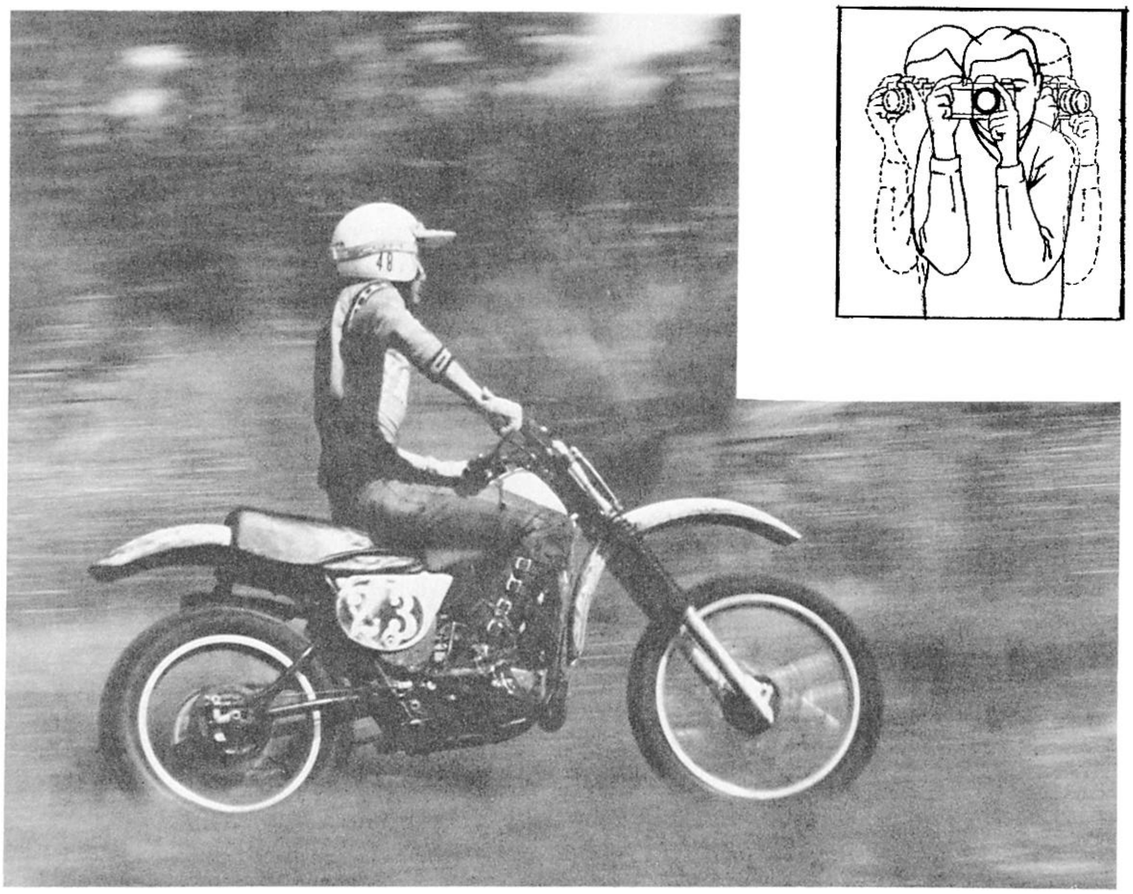

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Figure 4-17.–Panning with a moving object.

can be tolerated before it becomes objectionable and adjust your shutter speed accordingly. To determine what forms an objectionable blurring of the image, you must visualize how the photograph is going to be used. An image of a contact print can be much blurrier than an image that is magnified many times. A print that is viewed up close must be much sharper than a print viewed from a distance.

Once you know how the photograph is to be used, you can determine the shutter speed required to produce an acceptably sharp image. In some situations, it may not be possible to produce an image that is completely sharp. When you want a sharp image of a fast-moving object, use the **panning** technique. When using the panning technique, you move the camera and follow the action of the subject until you make the exposure. This method may blur the background but can provide a sharp image of a moving object even at relatively slow shutter speeds (fig. 4-17).

There are five factors that determine the distance an image moves on the film during exposure. You must consider these factors each time you photograph a moving object. These five factors are as follows:

1. The lens-to-subject distance
2. The lens focal length
3. The speed of the object perpendicular to the lens axis
4. The direction of movement
5. The exposure time

Whenever one of these five factors change, the distance the image moves during exposure also changes. The first four factors determine the speed that the image moves across the film. The fifth factor limits the time it is allowed to move, thereby limiting the distance of image movement.

Subject movement on the film plane is greatest when the subject is moving across the angle of view of the lens (perpendicular to the lens axis). For example, when the subject is moving straight towards or straight away from the camera, it may appear as though it is hardly moving and a fast shutter speed is not required to produce a sharp image; however, when that same subject moves at the same speed across the field of view of the camera, the speed of the subject appears much faster. A faster shutter speed is required to stop the action in this case.

The camera-to-subject distance also affects the amount of image movement at the film plane; for example, a car moving across your field of view at 55 mph from a distance of 700 yards appears to be moving slowly. The same car moving at 55 mph and only 15 feet away appears to be moving very fast; therefore, the closer a moving object is to the camera, the faster the shutter speed must be to capture a sharp image. When the subject is moving diagonally across your angle of view, movement is more apparent than when moving straight away or toward the camera, but less apparent than when moving straight across the field of view.

Remember, long-focal-length lenses exaggerate the effects of camera and subject movement, and short-focal-length lenses reduce the effect.

Experience and common sense are your best guides for determining shutter speed that will minimize image movement, but the following can be used as a guide to help make these determinations:

- Double the shutter speed when the subject speed is doubled.
- Halve the speed when the speed of the subject is halved.
- Double the shutter speed when the camera-to-subject distance is halved.
- Halve the shutter speed when the camera-to-subject distance is doubled.
- Double the shutter speed when the focal length is doubled.
- Halve the shutter speed when the focal length is halved.
- When in doubt, use the next higher shutter speed.

There are mathematical formulas used to determine appropriate shutter speeds for subjects moving at all speeds when photographed with various lenses, but the use of these formulas is not practical. Table 4-2 shows stop motion relationships when a 50mm lens is used. This table is not intended to be memorized but is only intended to provide a better understanding of the relationship of subject motion, distance, and direction.

COMBINING APERTURE AND SHUTTER SPEED

So far three camera controls have been discussed separately: focus, aperture, and shutter. Focus is the most straightforward because it is used to produce a sharp image of the subject. Aperture and shutter each affect the image in two distinct ways. They both control the amount of light that makes the exposure, and they both affect image sharpness. The aperture alters depth of field, and the shutter controls the image movement or blur.

The light-sensitive material must receive the correct amount of light to produce a quality photograph. Under most lighting conditions, it does not matter whether you use a wide aperture with a fast shutter speed or a small aperture with a slow shutter speed. When the combination is correct, both provide the same amount of exposure.

Aperture and shutter speeds each have a doubling and halving effect on exposure. This doubling and halving relationship of aperture and shutter allows you to combine different f/stops and shutter speeds to alter the image, while, at the same time, admitting the same amount of exposure to the light-sensitive material; for example, you have determined that the correct camera settings for your subject is 1/125 second, at f/16. Instead of using this combination of shutter speed and f/stop, you could double the shutter speed (to stop action) and halve the f/stop. In this example your new camera setting could be 1/250 second at f/11, 1/500 second at f/8, or 1/1000 second at f/5.6, and so on. Or when you need more depth of field, 1/60 second at f/22 or 1/30 second at f/32, and so on, can be used. These shutter speed and f/stop combinations are called equivalent exposures. Equivalent exposures are used to control depth of field and to stop motion. Table 4-3 shows some equivalent exposures of a typical situation.

Each of the combinations in table 4-3 produces the same exposure; however, the amount of depth of field and image blur are different in each image. The combination of shutter speed and f/stop is used to best capture the subject and effect you want to create.

You should use a light meter for most of the photographs you take. The light meter provides you with a number of f/stop and shutter speed combinations; however; depending on the situation, the level of light alone can determine the camera settings. For example,

Table 4-2.–Action Stopping Shutter Speeds for Normal-Focal-Length Lenses

Speed MPH	Type of Action	Distance	Direction of Action		
			Across Field of View	Diagonally	Straight Toward or Away
5	Slow walk, working with the hands	12 25 50 100	1/500 1/250 1/125 1/60	1/250 1/125 1/60 1/30	1/125 1/60 1/30 1/15
10	Fast walk/ work, slow-moving vehicles	12 25 50 100	1/1000 1/500 1/250 1/125	1/500 1/250 1/125 1/60	1/250 1/125 1/60 1/30
25	Running, sports, very active people, vehicles moving at a moderate speed	12 25 50 100	1/2000 1/1000 1/500 1/250	1/1000 1/500 1/250 1/125	1/500 1/250 1/125 1/60
100	Very fast-moving vehicles and aircraft	25 50 100 200	1/2000 1/1000 1/500	1/2000 1/1000 1/500 1/250	1/1000 1/500 1/250 1/125

Table 4-3.–Equivalent Exposures

Shutter Speed	f/stop
1/2000	f/4
1/1000	f/5.6
1/500	f/8
1/250	f/11
1/125	f/16
1/60	f/22
1/30	f/32
1/15	f/64

the light level may be so low that you have to use a slow shutter speed and the largest f/stop to get the proper exposure. After determining the correct exposure, you can decide how to present the subject. Remember, depth of field can be used to emphasize your subject, and shutter speed affects subject blur.

EXPOSURE CONTROL

The *term exposure* in photography means the amount of light that reaches the film or other light-sensitive material. The mathematical formula for exposure is the product of light intensity and the amount of time that the light acts on a light-sensitive material. There are two ways a formula is presented in photographic publications. They are as follows:

$$E = I \times T$$

and

$$H = E \times T$$

Where:

E or H = Exposure (lux-seconds or meter-candle seconds)

I or E = Intensity or illuminance (lux or meter candles)

T = Time (seconds)

Both of these formulas represent exposure. The second formula is presented in the more current publications.

As explained previously, camera exposures are controlled by the shutter speed and aperture. The shutter speed controls the time light is permitted to reach the film. The illuminance (or intensity as it is sometimes called) is controlled by the aperture of the camera. The term *illuminance* means the amount of light reaching the film plane. By adjusting these controls, you allow the correct amount of light to reach the film. The correct amount of light varies, depending on the film speed. Correct exposure for negative films is defined as the exposure required to produce a negative that yields excellent prints with the least amount of difficulty. Correct exposure for color reversal film produces color images in densities that represent the appearance of the original scene.

FACTORS THAT AFFECT EXPOSURE

You must consider four major factors that affect exposure when you are taking photographs. These factors are as follows:

- Film speed (ISO)
- Reflected properties of the subject
- Lighting conditions
- Bellows extension

Film Speed

As explained in chapter 2, ISO is a system of rating film speed or sensitivity to light. ISO numbers are arithmetic; that is, an ISO number that is twice as high as another ISO number is twice as sensitive to light. Each time an ISO film speed is doubled, the exposure should be halved. When the ISO is halved, the exposure should be doubled; for example, if the correct camera setting is 1/250 second at f/16 with ISO 100 film, the same subject photographed with ISO 200 film would require only half the exposure or 1/500 second at W16 or 1/250 second at f/22, and so on.

Daylight Conditions

The two primary considerations for determining your exposure under daylight conditions are the intensity and the direction of daylight.

INTENSITY.–From early morning until later evening, even on a clear day, the intensity of daylight is constantly changing as the sun rises, moves across the sky, and sets. Although the intensity of daylight varies throughout the day, the time between about 2 hours after sunrise until about 2 hours before sunset is considered a time when the light intensity for the same geographical location remains constant for exposure purposes.

Daylight conditions for camera exposures can be divided into the following five intensity conditions.

Bright Sun on Light Sand or Snow.–Bright sun is daylight that is not affected by any apparent atmospheric interference. Because of the amount of reflected light from sand or snow, the intensity of light in these scenes is greater than that of a scene with average reflectance. This greater intensity of light requires a higher f/stop or a faster shutter speed to provide approximately one half of the exposure required for the basic exposure with bright or hazy sun.

Bright Sun.–This type of daylight illumination is produced on a bright, sunny day where distinct shadows are present. Bright sun is the condition that determines the BASIC EXPOSURE for an average scene.

Cloudy Bright.–A weak, hazy sun is the result of a heavier or thicker haze or cloud cover as compared to the bright sun condition. The condition causes a decrease in the daylight intensity and an increase in the diffusion of daylight. This lighting condition produces shadows that are soft or indistinct. A lower f/stop or slower shutter speed is required to approximately double the basic exposure to compensate for this decreased daylight intensity.

Cloudy.–Cloudy conditions are the result of a layer of clouds that further reduce the intensity of daylight and diffuse the light completely. This condition occurs on an overcast day when the position of the sun can be located only as a bright area in the clouds. Shadows are not present under this lighting condition. The scene brightness range is low and therefore photographs made during this condition usually lack good contrast. An increase of four times (two f/stops) from the basic exposure is required to compensate for the decreased intensity of light.

Heavy Overcast or Open Shade.–This condition exists when the position of the sun cannot be located. The scene brightness range is low and therefore photographs made during heavy overcast conditions usually lack good contrast. An increase of eight times (three f/stops) to the exposure is required horn the basic exposure to compensate for the decreased intensity of light.

DIRECTION.–The direction of the sun or light source illuminating your subject also affects your basic exposure. The camera settings recommended for films

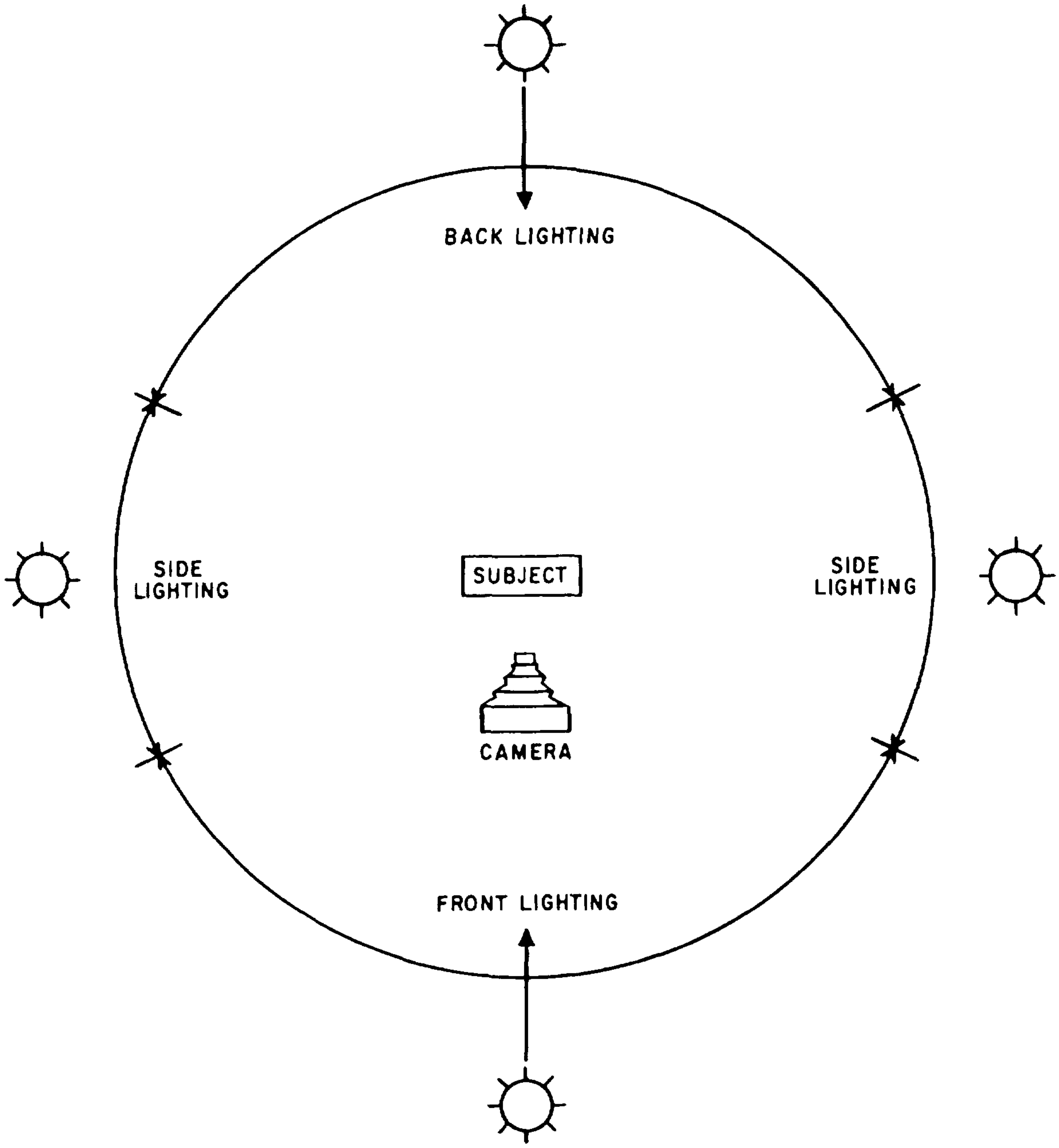

Figure 4-18.–Lighting directions.

exposed during bright sun on light sand or snow, bright sun, cloudy bright, and cloudy conditions are for scenes that are front-lighted only. The direction of the light source from heavy overcast or open shade conditions does not affect exposure because it is extremely diffused and the direction is not apparent.

The amount of light reflected from the scene changes, as the direction of the light changes. As the lighting direction is changed from in front of the subject to behind the subject, the amount of light reflected from the subject is reduced; therefore, depending on the direction from which the light is falling on your subject, you may have to compensate the camera exposure. There are three basic lighting directions with which you must become familiar. These lighting directions are as follows: frontlighting, side lighting, and backlighting (fig. 4-18).

Frontlighting.–Whenever light originates from behind the camera and illuminates the front of the subject, it is called frontlighting. A subject appears brightest and reflects the most light toward the camera when the subject is front-lighted.

Side Lighting.–As the camera is moved in an arc away from frontlighting, less light is reflected from the subject into the lens. Whenever the light source has a 90-degree relationship with the camera, the incident light on the subject is called side lighting. In side lighting situations, part of the subject is in shadow. Photographs of side-lighted scenes usually require two times (one f/stop) more exposure than frontlighted subjects when you want detail in the shadows.

Backlighting.–When the light source is directly behind the subject and aimed toward the camera, it is called backlighting. In back-lighted situations, the subject is in shadow and the light reflected from the subject toward the camera is decreased greatly. A silhouette effect (no shadow detail) of a back-lighted scene is produced by closing down one f/stop from the basic exposure. If shadow detail is desired, an increase of four times (two f/stops) from the basic exposure is required.

Reflection Properties

Otherwise the intensity and direction of light falling on the subject, the texture of the surface, and the colors and shades of the scene also have an effect on film exposure.

SURFACE TEXTURE.–Smooth, glossy surfaces scatter or diffuse reflected light very little; therefore, these objects reflect a large percentage of light to the lens. Rough surfaces greatly scatter and diffuse light. Less light from rough surfaces is reflected to the lens.

COLORS AND SHADES.–Not all light that falls on the surface of a subject is reflected. A brilliant white object reflects a high percentage of incident light, and a black object reflects very little of the light. Between these two extremes are the numerous tones of gray and colors of various hues and brightnesses. Each colored or gray object in a scene reflects a specific amount of light. A scene that consists primarily of light-colored or light-toned objects usually requires an exposure compensation to decrease the exposure as compared to the basic exposure for an average scene. A scene that consists primarily of dark-colored or dark-toned objects usually requires an exposure compensation to provide more exposure as compared to the basic exposure for an average scene. The primary reason light scenes and dark scenes require less exposure and more exposure, respectively, as compared to the average scene, is to maintain detail in the highlight of the light scenes and detail in the shadow areas of the dark scenes.

The color quality of a light source also has an effect on the amount of light reflected from an object; for example, a blue object does not reflect as much light when illuminated with a red light source, as compared to the same object being illuminated with a blue light source. This difference in reflectance is caused by the blue object absorbing the reddish light and reflecting the bluish light.

Any man-made light is an artificial light source. This light may be a tungsten lamp, a fluorescent lamp, a mercury-vapor lamp, and so on. The same factors that affect exposures for daylight apply to artificial light as well. Artificial light has some advantages. Distance, direction, and color temperature can be controlled using these light sources.

Bellows Extension

When copy cameras or view cameras are used, many subjects are photographed at very close distances. When you are photographing at these close distances, it is not uncommon for the bellows of these cameras to extend beyond one focal length. The farther the bellows are extended, the larger the image size produced at the film plane. When a 1:1 subject to image ratio (on the film plane) is needed, the bellows are extended to two times the focal length of the lens; for example, when a 6-inch lens is used to produce a 1:1 ratio, the bellows are extended to 12 inches. The distance the bellows are extended is determined by measuring the distance from the optical center of the lens to the film plane.

When the bellows are extended beyond one focal length, an exposure compensation is needed. Because light must travel a greater distance, some of the intensity is lost. This loss of light intensity must be compensated for by opening up the aperture or increasing the exposure time. There are two formulas used to adjust the exposure when the bellows are extended.

Generally, the exposure time is extended to compensate for bellows extension, because view cameras and copy cameras are mounted securely and the critical aperture is used to produce the sharpest image. To adjust the exposure time, use the following formula:

$$\left(\frac{BE^2}{FL}\right) \times T = NEW\ EXPOSURE\ TIME$$

Where: BE = Bellows extension

FL = Lens focal length

T = Indicated exposure time

EXAMPLE: You are photographing a document with a camera that has a 5-inch lens and the bellows are extended 7 inches. Your light meter indicated an exposure of 1/30 second at f/4. The new exposure time is determined as follows:

$$\left(\frac{7}{5}\right)^2 \times \frac{1}{30} = 1.96 \times \frac{1}{30} = \frac{1.96}{30} = \frac{1}{15} \textit{ SECOND.}$$

To adjust the aperture, use the following formula:

$$\frac{\textit{indicated f/stop} \times \textit{focal length}}{\textit{lens-to-film distance}} = \textit{adjusted f/stop}$$

EXAMPLE: A 4-inch lens is extended to 4 inches beyond one focal length. The original camera settings are 5 seconds at f/11. Using the above formula, the problem is solved as follows:

$$\frac{11 \times 4}{8} = \frac{44}{8} = 5.55 \text{ or } f/5.6.$$

f/16 RULE

You should use a light meter for most of the photographs that you take in the fleet. These light meters are either built into the camera or are separate hand-held models; however, there may be times when your light meter does not operate properly, or you do not have time to use it in order to "grab" an awesome shot. The f/16 rule of exposure allows you to determine basic camera exposure settings for both black-and-white and color photography without the aid of electronic devices.

The f/16 rule states: The basic exposure for an average subject in bright frontal sunlight is

$$\text{f/16 at: } \frac{1}{\text{film speed}}$$

Therefore, to calculate the BASIC exposure for bright, sunny conditions, set f/16 on the camera lens and use the IS0 speed of the film for the shutter speed; for example, when you use IS0 125 film, set the shutter speed at 1/125 second and the lens aperture at f/16. For IS0 64 film, set the shutter speed at 1/60 second and the lens aperture at f/16, and so on. When the camera does not have a shutter speed corresponding to the IS0 of the film, use the shutter speed that is closest to the IS0 of the film.

The f/16 rule is based on the correct exposure for an average subject under bright, sunny conditions. If the sun goes behind a cloud, however, then the lighting on the subject is decreased and you must change the basic exposure. The aperture settings for different daylight intensities are as follows:

- Bright sun on light sand or snow-f/22
- Bright sun-f/16
- Cloudy bright-f/11
- Cloudy-f/8
- Heavy overcast or open shade-f/5.6

For each of these different daylight intensity situations, you begin with the ISO speed to determine the shutter speed, set the aperture to f/16, and open up or stop down the aperture for the lighting conditions.

After calculating the exposure, you can change the setting to any equivalent exposure; for example, if you determine the required exposure to be 1/500 second at f/5.6 but you wish to use a small aperture for greater depth of field, you can change the setting to 1/60 second at f/16.

Remember, the f/16 rule provides you with a basic exposure for front-lighted subjects only. When the subjects are side-lighted or back-lighted, you must double or quadruple the exposure, respectively.

Because many cameras are fully automatic, you may wonder why you need to know basic exposure. There are three good reasons for knowing and understanding the basic principles of exposure. First, you want to control the depth of field and stop action instead of the camera controlling it. Second, a light meter cannot think All a light meter does is respond to the light it receives. You must know when to override the camera; for example, when the subject is side-lighted or back-lighted. Third, meters are mechanical and can fail. They can be inconsistent, consistently wrong, or fail altogether. When you can workout in your head, roughly what the camera exposures should be, you will know when the camera or light meter is wrong. Knowing when a light meter is giving incorrect readings could make the difference between success or failure of an important photographic assignment.

LIGHT METERS

The correct use of a light meter greatly increases the accuracy in determining your camera exposure. You should also understand that the incorrect use of a light meter can result in consistently unacceptable results. To assure consistently acceptable exposures, you must become thoroughly proficient with the correct operation of a light meter.

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Figure 4-19.–Hand-held light meter.

A light meter can be either built into the camera or a separate hand-held unit (fig. 4-19). Both types are sensitive instruments and should be handled with care. There is little maintenance, but they do require batteries. When you think a light meter is not working properly, have it checked by a qualified technician. Always be sure to check your equipment before leaving on an assignment. Like all camera equipment, careless handling and excessive heat and moisture limit the life of a light meter. A light meter must not be subjected to high temperatures for prolonged periods of time. Unless the light meter is designed for underwater photography, it should be protected in inclement weather.

LIGHT METER READINGS

There are two methods of measuring light with hand-held light meters. These two methods are the incident-light method and the reflected-light method.

Incident-Light Method

This method requires the use of an incident-light meter. An incident-light meter has a diffusing dome that covers the photoelectric cell. When an incident-light meter reading is taken, the meter is held at the position of the subject with the photoelectric cell pointed toward the camera. The meter measures the light falling upon the scene. The incident-light method of measuring light is used extensively in motion-media photography and gives fast accurate results in all photography.

Most light meters are designed for use as either incident-light or reflected-light meters. By removing the diffusion dome from the photoelectric cell, you can use the meter to measure reflected light.

Reflected-Light Method

When you are taking this type of light-meter reading, the diffusing dome should be removed from the photoelectric cell and the meter pointed toward the subject.

A reflected-light meter receives and measures the light reflected from a scene within the angle of acceptance of the meter. The term *angle of acceptance* compares to the term *angle of view* of a lens. Both are predetermined during manufacturing. The angle of acceptance and the distance between the meter and the scene are the controlling factors as to how much of the reflected light from the scene is measured by the meter. When the angle of acceptance is greater than the angle of view of a lens (when using a telephoto lens for example), the meter should be moved closer to the scene.

Light meters that are built into the camera are reflected-light meters. When these meters are used, the angle of acceptance is not greater than the angle of view of the lens being used. The meter measures the light from the scene as seen by the lens.

Some reflected-light meters have angles of acceptance between 1 and 4 degrees. These meters can be used from a distance to measure the reflected light from specific objects within a scene. Exposure meters with angles of reflectance this small are called **spot meters.**

LIGHT METER OPERATION

You must understand the way light meters operate to determine whether the information they provide is accurate. No matter what type of light meter you use, it is an electrical-mechanical device that can only provide information for which it is designed. You are responsible for translating this information into useful exposure data.

Light meters are calibrated to see one shade only-middle gray. This means the information that the meter provides, no matter how much light is falling on the subject or what the reflection characteristics are, reads the subject the same as though it were middle or neutral gray (18-percent gray). Theoretically, if you take a reflected-exposure meter reading from an 18-percent gray card and expose your film according to the reading, the result should be a picture that matches the tone of the gray card exactly; however, when you take a light meter reading of a white or black object, the light meter still reads the objects as though they were 18-percent gray.

When you take a photograph that includes a gray, white, and black card, you will see how, depending on where you take the light meter readings, they affect your photograph; for example, when you take the light meter reading from the black card, the final picture reproduces the black as middle gray, and the gray and white cards as white. When you take the reflected-light meter reading from the white card, just the opposite occurs. In your final picture, the white card reproduces as middle gray, and the gray and black cards reproduce as black.

This example demonstrates overexposure and underexposure. When the reading was taken from the black card, the meter raised the black tone to middle gray, and the gray card tone was also raised so it reproduced as white. Thus both the black and gray cards were overexposed The opposite occurred when the exposure was based on the reading from the white card. The white tone was lowered to middle gray and the gray card tone to black, resulting from underexposure. Only a light meter reading taken from the gray card allows all three cards to be imaged at their true tone.

A more practical example on the way a light meter reads 18-percent gray is illustrated in the following example. Suppose you are going to photograph a ship alongside a pier. Bright sunlight is striking the ship from the side, causing part of the ship to be in shadow. This creates a brightness difference between the highlight area and the shadow area. Both highlight and shadow areas are equal in size and importance. When you get close to the ship and take a reflected meter reading of the highlight area alone, you expect the finished photograph, like the white card in the above example, to be middle gray. When you stop down the aperture to the recommended exposure of the meter, you are also reducing the amount of exposure from the shadow area. This results in a loss of detail in the shadow area of the ship, because it is underexposed. The opposite effect occurs when you take a meter reading from the shadow area. In this case, the shadow tones are raised to middle gray and have detail, but the highlights are overexposed and completely "washed out."

If, however, there was an area in this scene whose tone was midway between the highlight and shadow areas, you could use it to take your light meter reading (like the gray card was used in the previous example). In this example, assume there is no tone midway between the two extremes. You can still get an accurate light meter reading of the entire ship. Since the highlight and shadow areas are of equal size, the *average* light meter reading you get will represent a tone that is midway between the two extremes.

REFLECTED LIGHT METER READING VARIATIONS

There are variations of light meter readings used to provide accurate light meter readings of different types of scenes. These methods are as follows: the integrated, or average, method, the brightness range method, the darkest object method, the brightest object method, the substitution method, and the bracketing method.

Integrated, or Average, Method

The technique of making reflected-light meter readings from the camera position is called the *integrated,* or *average,* method. This method was used and explained in the examples above. This method is accurate for the majority of photographs taken.

The integrated, or average, method of measuring reflected light is acceptable for scenes that consist of approximately equal portions of light and dark areas; however, when a scene is composed of either predominately light or dark areas, the meter reading may not be accurate.

The reason for these inaccurate meter readings can be more easily understood by using an example of photographing a checkerboard with alternating black-and-white squares. When the meter is held at a distance to include the entire board, the reflected light from both the black and the white squares influence the meter, so an average reading results. The light measured from this position is the integrated sum of both the white and the black squares, as though the checkerboard were one gray tone. The light meter reading from this point should produce an acceptable image.

If you hold the meter so close to one of the white squares that the black squares have no effect on the meter reading, the reading is higher than the integrated reading and the meter indicates that the scene requires less exposure. The same principle applies when a reading is taken close to a black square. The reading indicates that the scene requires more exposure. Each of the meter readings is a measurement of 18-percent gray. You can apply this checkerboard example when you photograph scenes that are predominately light or dark Compensation is required to expose such scenes correctly.

As a general guide, you should double the indicated exposure when the light measurement is taken from a predominately light scene and detail is desired in the shadows. When you take a light meter reading from a predominately dark scene and detail is desired in the highlight areas, you should reduce the exposure by one half.

Brightness Range Method

This method requires you to take two readings from the scene: one from the highlight area where detail is desired and another from the shadow area where detail is desired. You then base your exposure on a point midway between the two readings.

The brightness range method of determining exposures for most scenes usually provides detail in both the highlight and the shadow areas. An exception to this is when the exposure latitude of a film is not capable of recording the brightness range of the scene. This can occur with scenes that have extremely great brightness ranges. A scene brightness range is the difference between the brightest and the darkest areas of a scene and is usually expressed as a ratio. The average brightness range of a normal scene is 160:1. Films used for pictorial work are capable of reproducing this brightness range. When the scene exceeds a brightness range of 160:1, you must compromise the exposure. This compromise can be as follows:

- Underexpose and sacrifice shadow detail to retain highlight detail.
- Overexpose and sacrifice highlight detail to retain shadow detail.
- Do not compensate and expose for the midtones and sacrifice both highlight detail and shadow detail.

Darkest Object Method

The darkest object method of determining exposures is actually a variation of the brightness range method. When you desire detail in the shadow area or darkest object within the scene, you take the light meter reading from this area. This method actually overexposes the film overall, causing the highlight areas of the scene to be greatly overexposed. This overexposure occurs because the light meter averages the light reflected from the shadow area and indicates an exposure to produce middle gray. When a great amount of detail is not needed in the shadow area and you want to expose the overall scene normally, you can take your light meter reading from the darkest object or shadow area and stop down two f/stops. This method provides a good overall film exposure of the shadows, midtones, and highlights.

Brightest Object Method

Another variation of the brightness range method is the brightest object method. The brightest object method of calculating exposures is used when a highlight area within a scene is the only area within the scene from which you can take a light meter reading. This method can also be used when you want to record detail in the highlight area In both situations, you take only one light meter reading of an important highlight area. When you do not want the highlight to record as a middle-gray tone and desire a good overall exposure of the scene, you simply open up two or three f/stops from the indicated exposure. When you need maximum detail in the highlight area, you can use the reading that the light meter provides. This records the highlight area as medium gray. This method underexposes the film in other areas of the scene that reflect less light.

Substitution Method

With the substitution method, you replace an object within the scene with an object, such as a gray card. You then take a reflected-light meter reading from this object. You use this method when the other methods of determining exposure are not possible. Such situations may be caused by excessive distance between the light meter and the scene, barriers in front of the scene, or the size of the scene makes it impossible to get an accurate light meter reading. The substitution method is often used in studio situations where objects may be too small to obtain an accurate light meter reading.

You should select substitution objects that match the light reflectance quality of the object in the scene; for example, a white card can be used to substitute highlight areas of a distant scene. A dark or a black card can be used to substitute a shadow area, an 18-percent gray card can be used to represent middle gray, or the back or palm of your hand can be used to substitute a gray tone.

When the substitution method is used, take the light meter reading from the substituted item under similar lighting conditions that exist in the scene. When the scene is in bright sunlight, the substituted object must also be in bright sunlight. Likewise, a scene in shade requires a substitute light meter reading in shade.

You can use each of the methods discussed previously with the substitution method. An 18-percent gray card can be used for the integrated or averaging methods, a dark and a light card can be used for the scene brightness range method, a dark card for the darkest object method, and a light card for the brightest object method.

Bracketing Method

There are times when unusual lighting or subject brightness prevents you from getting an accurate light meter reading. In these cases, a good insurance policy is to bracket your exposure. To bracket, you should take one picture at the exposure indicated by the light meter, and then take two more exposures: one at one f/stop under the indicated exposure and another at one f/stop over the indicated exposure.

When you are in doubt about the correct exposure for a negative type of film, it is always better to overexpose than underexpose. Even though overexposure produces excess densities in the negative, it still provides a useable image that can normally be corrected in the printing stage. When underexposed, if the image does not exist on the film, no corrective printing techniques can provide image detail.

When shooting reversal film (slides), you should bracket in 1/2 f/stop intervals. Because the exposure latitude of slide film is limited to ± 1/2 f/stop, you should bracket in 1/2 f/stop increments, both under and over the indicated light meter exposure reading. Color slides that are 1/2 f/stop underexposed have more color saturation and are more usable than ones that are 1/2 f/stop overexposed and appear “washed out” and light.

TAKING LIGHT METER READINGS

When taking light meter readings, you must be sure the reflected light that influences your light meter is actually from the object you want to photograph. Stray light, backlighting, large dark areas, and shadows can all cause erroneous light meter readings. When using a light meter, be sure that shadows are not cast from the light meter, camera, or yourself. When a hand-held light meter is used, the distance of the light meter to the subject should not exceed the shortest dimension of the object; for example, when taking a light meter reading of a person’s face that is approximately 9x6 inches, you should hold your light meter about 6 inches from the face of your subject when taking the meter reading. When using a light meter that is built into a camera, be sure to focus on the image before taking a light meter reading.

CAUSES OF FALSE LIGHT METER READINGS

There are a number of reasons why light meters give erroneous or bad readings that produce underexposed images. You can prevent these bad readings by being aware of the conditions that cause them.

Light Entering the Viewfinder

Light entering the viewfinder and falling on the viewing screen can cause underexposure. Most TTL meters read the light falling on the viewing screen from the lens. When strong lighting is coming from behind the camera, it can influence the light meter. When an occasional underexposed frame in an otherwise successful series occurs, the cause may be light entering the SLR viewfinder. Make a point of shielding the viewfinder if you do not have a rubber eyecup. When you use a tripod, have the camera set on automatic and cap the viewfinder to prevent exposure errors.

Incorrect Film Speed Setting

When the majority of frames on a length of film are consistently underexposed or overexposed, the most likely cause is you have the wrong ISO set on the film speed dial. For black-and-white film and color reversal film, it may be possible to compensate for this in developing if detected before the film is processed.

Bright Subject

A bright object or highlight area can affect the sensing area of a spot or center-weighted TTL meter. This results in an underexposed image. To prevent this from occurring, you should ensure the sensor is pointed directly at a midtone within the scene, and use this as the camera exposure. When you frame and compose

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Figure 4-20.–4x5 Graphic View II camera.

your image, the light meter may indicate a different setting. Be sure to leave your camera set at the indicated midtone setting. Normally, light meters that take integrated or averaged readings of the field of view cannot be fooled in this instance. But remember, even integrated systems cannot cope with extremely bright areas that take up a significant portion of the frame.

Bright Background, Dark Subject

When you are taking photographs that are back-lighted or against a light background, there is always the danger of underexposing the main subject (unless you use special techniques to fill in shadows, such as using a reflector or a flash unit). Be careful to take a reading from only the shadow side of the subject in these situations.

Too Little Light

The most frequent cause of underexposure is trying to take pictures when there is not enough light. Light meter readings are not very accurate at these low-light levels. When you want to make photographs under these conditions, be sure to use a tripod and bracket to provide more exposure than indicated by the light meter. You also can switch to a higher IS0 film. Some of the high-speed films marketed today can provide remarkable results.

There are several other causes that may cause your images to be exposed incorrectly. Some of the most common causes are listed as follows:

- Wrong camera settings are set when transferring information from a hand-held light meter to the camera. This can also occur when you attempt to override an automatic camera.

- Using a camera with TTL metering and placing a color filter with a high-filter factor over the lens.
- Wrong aperture setting when flash is used.
- Shutter speed is not synchronized with camera flash.
- Aperture or shutter speed setting is knocked while carrying the camera. Always check the camera setting before taking a photograph.
- Weak or incorrect battery in the light meter.

VIEW CAMERA

The view camera (fig. 4-20) is a flexible and useful camera that, due to laziness, is frequently overlooked by Navy imaging personnel. Through the use of rising or falling fronts, swings, tilts, and shifts, you have complete control over the composition of the subject. View cameras are excellent for photographing construction, large groups of people, landscapes, small parts, damaged material, buildings, and many other subjects, because distortion can be controlled or corrected The camera has bellows that may be extended to make it suitable for copy work and photographing small objects. Most view cameras used in the Navy use 4x5 sheet film. View cameras are not suitable for sports or uncontrolled action situations where a hand-held camera is needed.

View cameras do not have viewfinders or range finders. Viewing and focusing is done on ground glass. The ground glass is located exactly the same distance from the lens as the film; therefore, the image viewed on the ground glass is the same that is recorded on the film. View cameras have interchangeable lenses and between-the-lens leaf shutters.

BASIC CONTROLS AND FUNCTIONS

All view cameras are basically the same. Generally, all view cameras have the following standard parts:

- Monorail or bed. Serves as the base or support to hold all the other components.
- Front lens standard. Permits the lens to be locked into any position on the monorail. The front lens standard also permits the lens to swing, slide, tilt, rise, and fall.
- Rear standard. The rear standard holds the film holder and has swing, tilt, and slide controls.

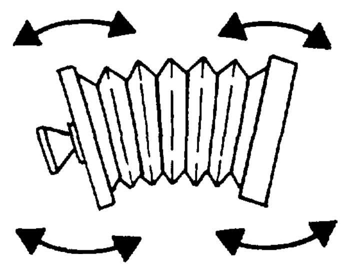

Figure 4-21–Swing movement of front and rear standards.

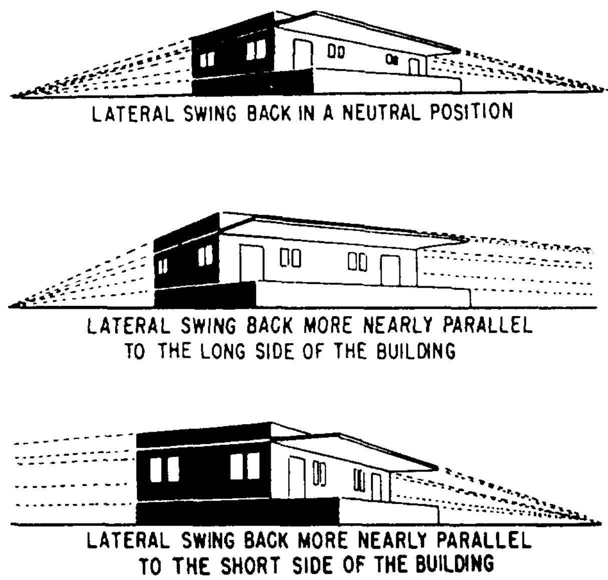

Figure 4-22.–Correction for horizontal distortion.

- Bellows. Connects the front and rear standards and allows the two standards to move for focusing or to accommodate various focal-length lenses.
- Tripod head. Holds the monorail to the tripod.
- Lens.
- Ground glass. Used for focusing, viewing, and composing the image.

There are four basic movements or adjustments used on a view camera. These basic movements perform specific functions. The four basic movements are as follows:

1. **Horizontal or lateral swing.** Both the front and rear standards swing horizontally (fig. 4-21).

The swing back is used to correct distortion, or perspective, in the horizontal plane. When you are photographing subjects from an angle, horizontal lines appear to converge at the distant side. To correct this distortion, swing the camera back so it is more parallel to the horizontal plane of the subject (fig. 4-22).

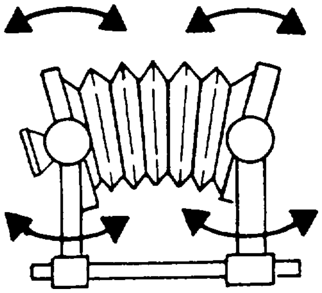

Figure 4-23.–Front and rear vertical tilt movement.

The front standard swing allows the lens to pivot horizontally around its optical axis. The swing front is used to increase the depth of field. When the swing back is swung, the film is not parallel with the image produced by the lens. By swinging the lens, you can bring the image onto the same plane as the film.

2. Vertical tilt. Both the front and rear standards tilt vertically (fig. 4-23).

The tilt back is used to correct distortion, or perspective, in the vertical plane. When you angle the camera up to photograph a subject, such as a building, the vertical lines on the ground glass appear to converge. When this distortion is not corrected, the subject appears smaller at the top and the vertical planes bend toward the center of the image (fig. 4-24, view A). To correct this distortion, tilt the tilt back so it is parallel to the vertical plane of the subject (fig. 4-24, view B).

The tilt front is used to focus and increase the depth of field. When the tilt back is tilted to correct for vertical distortion, the film plane is no longer parallel to the image produced by the lens. By tilting the front standard, you can bring the image of the lens onto the same plane as the film.

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Figure 4-24.–Uncorrected and corrected vertical distortion.

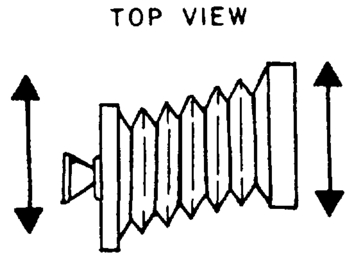

Figure 4-25.–Sliding front and rear of view camera.

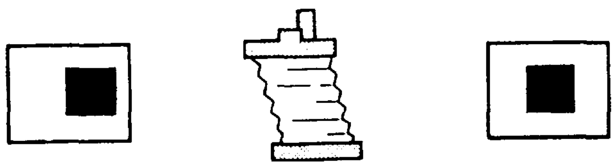

Figure 4-26.–Using sliding controls to center image.

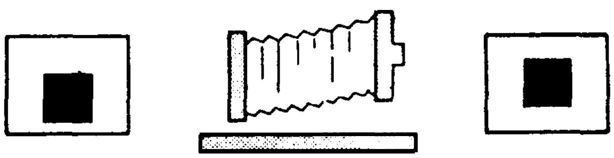

Figure 4-27.–Using rising and falling front-to-center image vertically.

3. Slide or shift. Both the front and rear standard shift or slide from side to side (fig. 4-25).

The sliding front or sliding rear is used to center the image on the ground glass horizontally (fig. 4-26). The sliding front or sliding rear is used when the image is not centered after the camera is set on a tripod. These controls are used instead of moving the tripod. When the tripod is moved, the horizontal corrections are altered and must be reevaluated.

4. Rising and falling front. The rising and falling front is used to center the image vertically on the ground glass (fig. 4-27). This control raises and lowers the lens board. This prevents you from tilting the entire camera and nullifying the distortion corrections made on the vertical plane.

VIEW CAMERA OPERATION

The view camera is easy to use, but this requires some thought and patience to use it properly. The more the camera is used, the more comfortable you will be with it. The following progressive steps are used when using the view camera:

1. Set up and level your tripod.

2. Set the camera controls to the neutral position. The neutral position is the starting point for photographs taken with a view camera. In the neutral position, all controls are lined up and no corrective movements are set. Adjust the front and the rear standards so they can be moved to focus the image.

3. Open the shutter and set the diaphragm at maximum aperture.

4. Roughly compose the image on the ground glass.

5. Focus the image.

6. Check the image size and subject coverage. When required, change lens focal length, camera-to-subject distance, or both. Small image size adjustments may be made by sliding the monorail forward or backward.

7. Correct distortion by using the swing and tilt controls. The image must be refocused after each control is moved.

8. Recenter the image horizontally by using the sliding front or the sliding rear. The image is recentered vertically by using the rising and falling front.

9. Refocus the image. To obtain greater depth of field, swing or tilt the lens board so it is parallel with the film plane.

10. Refocus.

11. Determine your exposure. When necessary, be sure to take the bellows extension into account.

12. Stop down the diaphragm and check the depth of field.

13. Check the circle of illumination. You will loose the circle of illumination when extreme camera

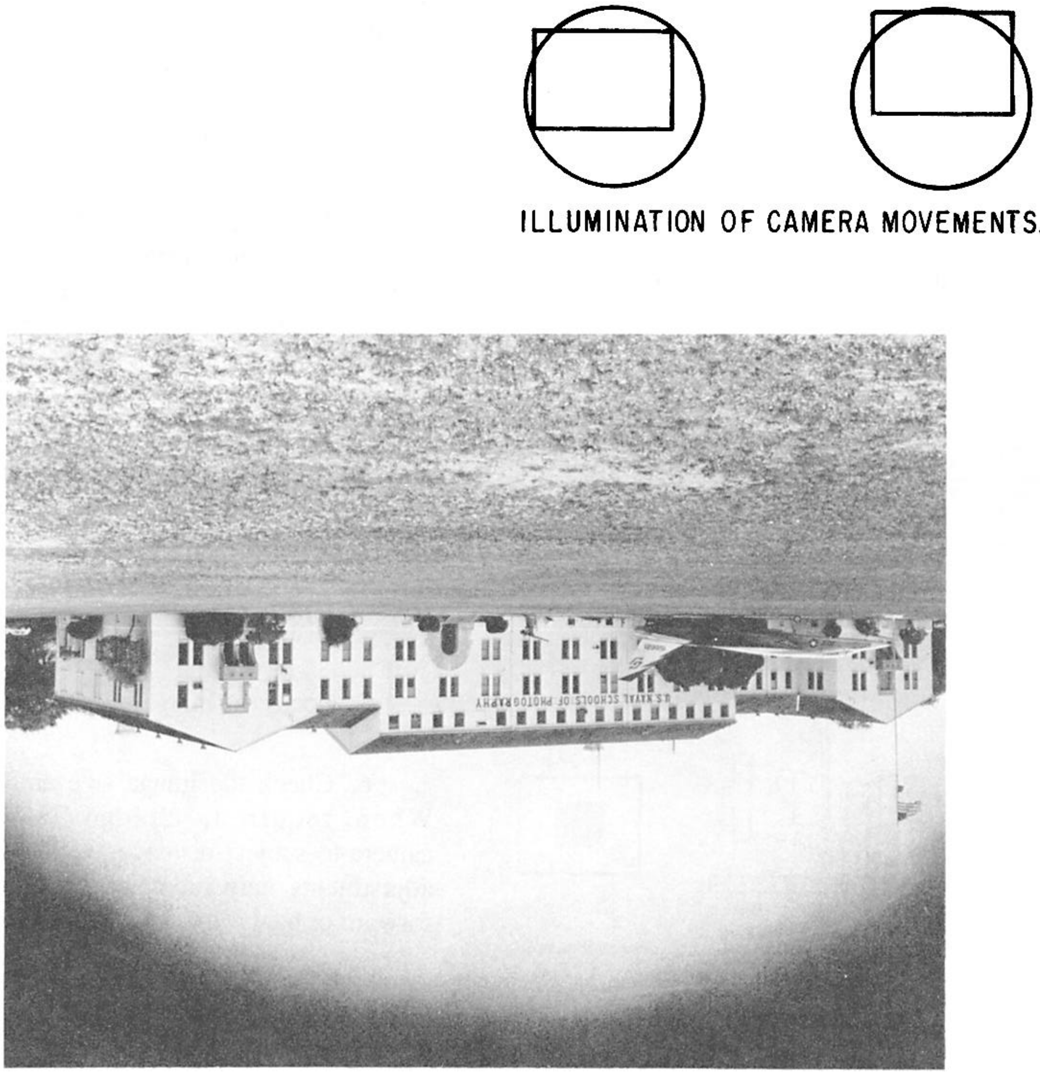

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Figure 4-28.–How the loss of the circle of illumination appears on the ground glass.

movements are made. This is caused when the lens field of coverage is shifted from the film plane (fig. 4-28).

14. Be sure all camera adjustments are locked down and insert the film holder. Be sure the lens is closed before removing the dark slide.

15. Make your exposure.

You cannot always correct 100 percent of the distortion. Horizontal or vertical distortion can only be corrected on one plane; for example, when you take a three-quarter photograph of a building, only the front or side can be corrected at a time, not both in the same picture.

ELECTRONIC CAMERAS

Still-electronic cameras are becoming popular in all branches of the Department of Defense. The operation of still-electronic cameras is basically the same as conventional cameras. The only difference between these cameras is the way the images are recorded and stored. There are two different types of electronic cameras used currently in the Navy: the still-video camera and the digital camera.

The Sony ProMavica MVC-5000 (Magnetic Video Camera) is an example of a still-video camera. The ProMavica records images as magnetic impulses on a compact 2-inch still-video floppy disk. The images are captured on the disk by using two-CCD (charge-coupled device) chips. One chip stores luminance information, and the other separately records

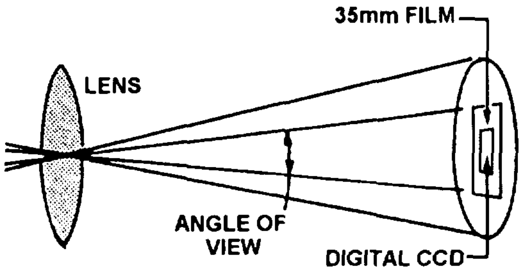

Figure 4-30.–Comparing the angle of view of a 35mm camera and the Kodak DCS Digital camera.

the chrominance information. This camera provides a 720,000 pixel image.

The images can be stored on the floppy disk either as a **FRAME** or a **FIELD.** When *frame* is selected, each picture is recorded on two tracks and up to 25 images can be recorded on each disk. When *field* is selected, each picture is recorded on only one track, allowing up to 50 images to be recorded. When you record your pictures in the field mode, images are less detailed as compared to images recorded on two tracks (frame).

Overtaking the still-video camera is the digital camera. The Eastman Kodak Company is leading the way in digital-imaging technology by introducing the Digital Camera System (DCS). Resolution with the Kodak DCS 200 Digital camera is 1.54 million pixels, providing four times the resolution of a still-video camera. Kodak's fully digital systems use a Nikon body and optics to capture the image. The image is then transferred to a highly sensitive CCD that converts the image directly into digital information. The CCD in the Kodak DCS camera system only uses a small portion of the angle of view compared to conventional cameras; for example, a 28mm lens on the Kodak DCS Digital Camera is equivalent to an 80mm lens on a 35mm camera (fig. 4-30).

The exposure index (EI) of the DCS camera equates to 50 to 400 IS0 for color images and 100 to 800 IS0 for black-and-white images. The digital images stored on the DCS camera can easily be downloaded to a computer, so it can be manipulated and printed or can be transmitted around the world without loss in quality. The image in figure 4-31 was transmitted directly from the USS *Ranger* CV-61 via satellite to the Navy News Photo Division in the Pentagon.

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Figure 4-31.–Image captured and transmitted using the Kodak DCS Digital camera.